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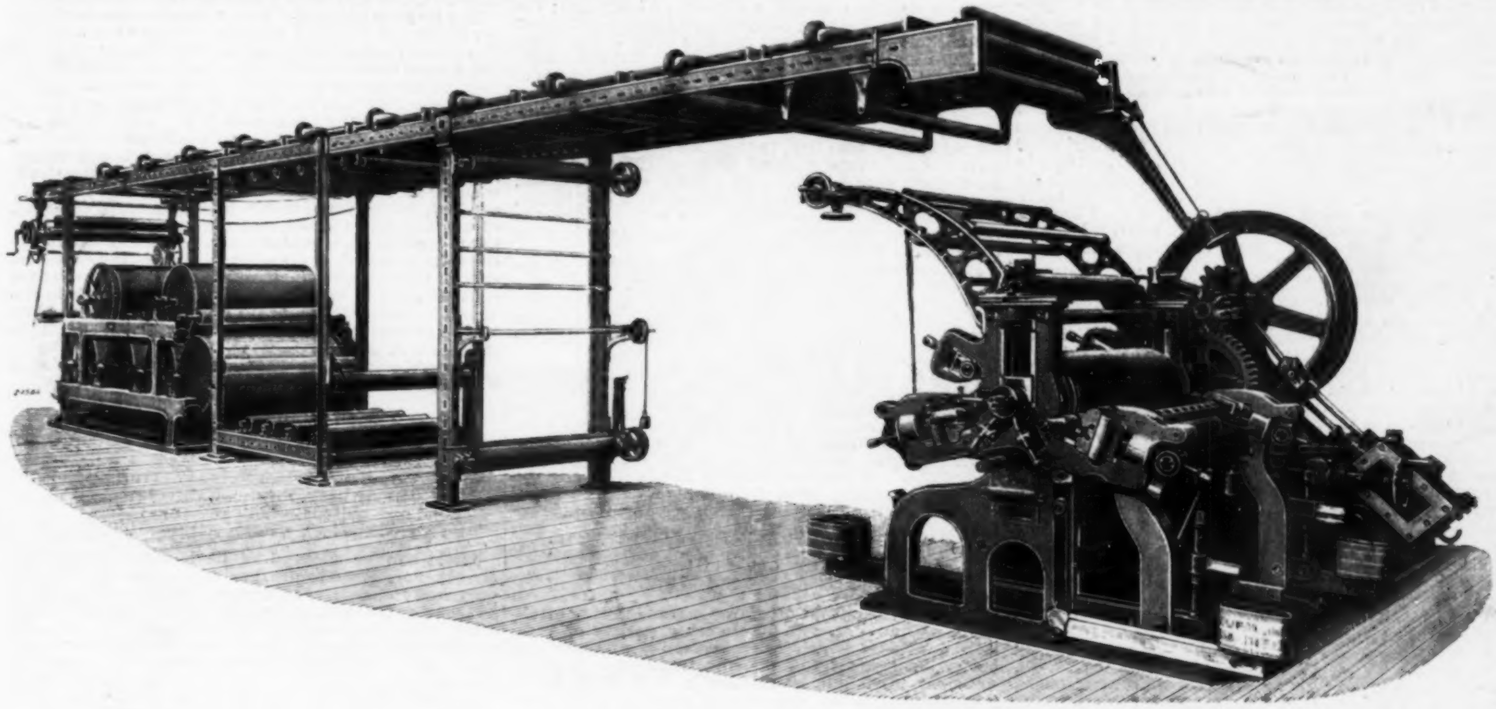
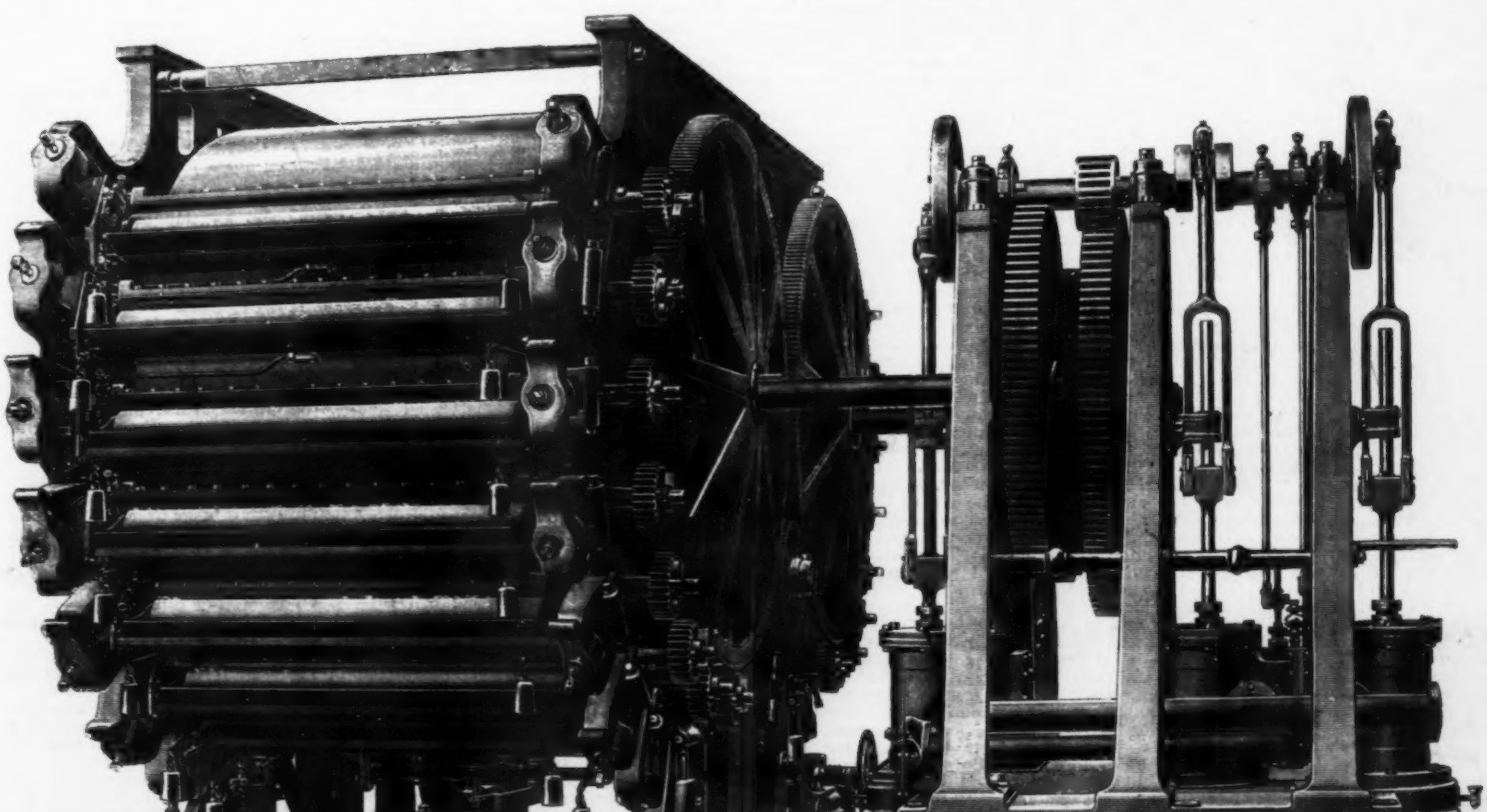


THREE COLOR FABRIC PRINTING MACHINE.



DUPLEX FABRIC PRINTING MACHINE.

FABRIC PRINTING MACHINES.

The meeting of the Institution of Mechanical Engineers, at Manchester, on the 31st of July last, was made the occasion for the production, in Engineering, of an elaborate illustrated description of some of the large cotton manufacturing establishments of the great industrial city. We present herewith two illustrations with particulars, for which we are indebted to our enterprising contemporary.

Our first illustration gives a general view of what is known as a three-color fabric printing machine and steam engine, together with the arrangements for drying the cloth after it has passed through the machine and the pattern has been printed. The working of the machine, which is for printing on one side only of the cloth, is as follows:

The pattern to be printed is engraved upon copper rollers. These rollers are placed upon mandrels in bearings or "nips," arranged in rotation and radial to the bowl or cylinder of the machine. The cloth is first batched upon an axle or center, supported on projecting arms, or "horns," placed at the back of the machine. This center is controlled by a hand brake for regulating the tension on the cloth in passing through the machine. The metal cylinder, or "bowl," is wrapped with several folds of strong cloth, and these, together with a continuous and endless woolen blanket, form the printing pad upon which the engraved rollers acting upon the cloth press. The colors are distributed upon the engraved rollers by wood rollers revolving in copper boxes filled with color, and in contact with the engraved rollers, the color which adheres to the unengraved portion being removed by flat steel bars, or "doctors." A second set of bars is provided for removing the fluff or lint from the rollers; these are termed "linting doctors."

On leaving the machine the cloth travels past a series of pipes or chests heated with steam, by which the colors are set, and then passes over steam heated revolving cylinders to complete the drying. The blanket which supports the cloth as a pad during the printing is also passed over a separate set of drying surfaces, and being arranged in endless form passes into and out of the machine continuously while the cloth is folded and removed to the finishing department.

The other illustration represents a class of printing machine which has been comparatively recently introduced for a special class of work, known as "duplex," or "double-sided" printing, in which the same pattern may be produced on both sides of the cloth. This machine may perhaps be better understood by describing it as a combination of two machines with their back rollers omitted. There are two printing cylinders, or bowls, revolving in opposite directions, but at the same speed, each having its own set of printing rollers. As in the case of ordinary or single sided printing machines, each cylinder or bowl has its own arrangement of continuous blanket. The cloth to be printed is led into the machine on the underside of the back bowl, passes upward between it and its set of printing rollers, then taking a downward course, passes from the back bowl to the front one, and between it and its set of printing rollers. Thus both sides are presented to the two sets of similar rollers alternately. Though primarily a duplex machine, it is so arranged that the cloth may be presented on one side only to all sixteen printing rollers, thus enabling any number of colors up to sixteen to be printed on one side of the cloth. For this purpose, however, the two bowls have to be made to revolve in the same direction; the general arrangement of color furnishing, cleansing, etc., is similar to that of the ordinary single-sided machines. The special feature of the machine illustrated is that one bowl with its side frames and set of printing rollers is adjustable in parallel lines bodily toward, or away from, the other bowl. This arrangement facilitates the lapping of the bowls, and by allowing them to be brought very close together prevents the cloth from stretching as it passes from one bowl to the other, thereby securing an accurate register or coincidence of pattern on the two sides. Another advantage accruing from this method of construction is that the relative positions between the two sets of printing rollers and their respective bowls remain undisturbed while adjusting the distance between the two bowls.

Another class of printing now being developed is termed intermittent printing, so called on account of the intermittent action of the printing rollers during the printing of the class of goods known to the trade as shawls, dresses, saries, chowls, etc., chiefly made for the Indian and other Eastern markets. The patterns in this class of work are usually divided into three different engraved parts, termed the "tail" or "crossbar," the "filling," and the "border." The border rollers run continuously in contact with the cloth except in patterns where the border stops short at the crossbar. The crossbar rollers print at predetermined intervals only, and directly they fall out of action the filling rollers come in contact with the cloth and print until it is their turn to drop out. The pressure required for a clear impression of certain designs is considerable, and as the action of lifting must be rapid to insure a well-defined "cutting" line across the piece to form an accurate joint in the patterns, it is essential that the machines be made exceedingly strong and rigid. This class of work has been on the markets for many years, but has mainly been produced by hand labor, machinery, in its practical usefulness, being of comparatively recent date.

Since the adoption of machinery the developments have been rapid, and many arrangements of mechanism more or less satisfactory have been employed. The firm of Thomas Gadd have made a departure from the ordinary methods of producing the required intermittent action, by the introduction of electricity as the principal factor in the automatic operations on the various rollers. It is a ten-color machine, six of the nips being fitted with intermittent mechanism. One great advantage claimed for the machine is that the changes in order to print various lengths (usually ranging from one or two yards up to ten yards or so) of shawls, etc., may be effected in a few minutes, whereas hitherto such changes have taken hours and sometimes even days.

Whites are not so well gifted in hearing as the colored races. Neither can white animals hear so well as those of other hues.

GREEK MEETS GREEK.

By S. W. Streeter.

In these days of exhaustive research, when untrodden fields are eagerly sought and explored secrets long withheld are wrung from the silent and reluctant past, sepulchers are remorselessly ransacked, buried cities unearthed, inscriptions laboriously deciphered, and pyramids resolutely penetrated, it is somewhat surprising that one subject of inquiry, vitally affecting human welfare, seems thus far to have withstood the curious questioner, if, indeed, a thought has been awakened.

Aside from the scientific specialist and bibliomaniac, nearly every household has its collector of stamps, birds' eggs, buttons, or butterflies, cards, coins, curios or ceramics, jews' harps or jewels, pipes, spoons or violins. The farm houses have been raided and relieved of tall clocks and spinning wheels, spinets and reels, cracked mirrors and crippled furniture, but it still remains for us to hear of the key collector.

The printer simulates ancient forms of type, the modiste develops quaint costumes of long ago; the new styles are the old; samples and tapestries become a fad, the resurrected past appears even in the latest fashions and household decorations. But the simple oak chest in which were deposited the crown jewels of Scotland would hardly be desired for such a trust now, though it was subjected to unhallowed violence when the keys were lost, for the three locks were too intricate for the skill of that day, though a bent skewer would have opened them without effort or difficulty. Our forefathers were satisfied with a brick or stone closet, closed with a door of wood, furnished with iron bands, hasps, staples, and padlocks. We can imagine the fiendish glee with which a modern burglar would overcome such a barrier to his entrance.

It is needless to enlarge upon the eternal vigilance to which the man of wealth is subjected, or upon the outraged sensibilities of those who find even the resting place of the beloved dead despoiled. In the eager strife for riches, how few think of the difficulties attendant upon its quiet, unmolested enjoyment!

When all were bunglers, clumsy means of securing valuables were employed; but now so much astuteness has been developed, from the petty pilferer to the professional cracksman, that skill must be met with skill, the most ingenious devices, the most baffling contrivances, must more than match the cunning of the archplotter. We seldom think of the debt we owe the mechanical expert, who, from the very substance of his brain, by creative power, supplies facilities for resistance to these constant attacks upon treasure and store.

"When Greek meets Greek,
Then comes the tug of war."

Examine the output of a large manufacturing establishment and note the bewildering variety of keys, locks, and safes which have become a necessity as a protection against the thieving fraternity. What a comment upon our civilization is this array, in its gradations from the tiny bronze padlock to the ponderous affairs for jails and burial vaults; from the simple device to check meddlesome children and untrustworthy servants to the complicated and ingenious mechanism requisite to withstand any assault of the professional burglar; from the plain bolt or warded lock, worth, perhaps, twenty-five cents, to the combination safe locks, automatic, magnetic, or chronometer, valued at hundreds of dollars!

We read of so called "heathen," among whom the property of another is inviolate, who would leave a purse untouched upon the highway until the owner should seek it. Rural communities, too, may leave doors and windows unsecured day and night; but an unspeakable burden is laid upon the majority of people by this predatory class, which has been a factor, doubtless, in social problems from the earliest periods, and has added a new significance to the injunction to "lay up treasure in heaven, where neither moth nor rust doth corrupt, and where thieves do not break through nor steal."

When wealth consisted in flocks and herds, possessions were in land, and homes were in tents, a delightful simplicity, indeed, must have prevailed; but with apartment houses a necessity for lock and key arose. With acquisitions of precious stones, or metals, or whatever might properly be called "treasure," the instinct which prompted our grandmothers to stow their purse in an improvised pocket afforded by their raiment, must have manifested itself in the very infancy of the race, as they tucked away their valuables in the bosom of Mother Earth, who, alas! often proved recreant, surrendering her trust to the wrongful seeker, or by some freak withholding it forever, as in the case of the traditional spoils of Captain Kidd.

The antiquity of locks and keys, however, may be inferred from numerous allusions, centuries before the Christian era. In Solomon's Song we find this passage: "I rose up to open to my beloved, and my hands dropped with myrrh, and my fingers with sweet-smelling myrrh, upon the handles of the lock;" and in Nehemiah, "But the fish gate did the sons of Hassenaah build, who also laid the beams thereof, and the locks thereof." In these quotations no key is mentioned, but in Judges we read, "Ehud went forth through the porch and shut the doors of the parlor upon him and locked them. When he was gone out his servants came, and when they saw that behold the doors of the parlor were locked, they said, 'Surely he covereth his feet in his summer chamber,' and they tarried till they were ashamed, and behold, he opened not the doors of the parlor; therefore they took a key and opened them."

The most ancient lock ever discovered is that described by Mr. Bonomi as having secured the gate of an apartment in one of the palaces of Khorsabad, Nineveh. It was fastened by a large wooden lock like those still used in the East, of which the key is as much as a man can conveniently carry, and by a bar which moved into a square hole.

Doubtless the prophet Isaiah alludes to a key of this description when he says, "The key of the house of David will I lay upon his shoulder." The word for key in this passage of Scripture, it is said, is the same in use all over the East at the present time. The key of an ordinary street door is commonly thirteen or fourteen inches long, and the key of the gate of a public building, or of a street, or quarter of a town, is two feet and more in length. A merchant of Cairo may be seen carrying the keys of his magazine over his shoulder. The iron pegs at one end of the piece of wood correspond to holes in the wooden bar or bolt of the lock, which, when the door or gate is shut, cannot be opened till the key has been inserted and the impediment to the drawing back of the bolt removed by raising up so many iron pins that fall down into holes in the bar or bolt, corresponding to the peg in the key.

The modern key of Mosul, in the vicinity of what remains of ancient Nineveh, is a long bar of wood, with two projections toward the end about a foot in length, "well calculated," as one traveler says, "not only to open a door, but to knock down any one who might attempt to enter without permission." The invention is ascribed by Pliny to Theodore of Samos, 730 B. C., but keys are mentioned in the siege of Troy, 1193 B. C. The discovery of the pin lock and the figure of one being sculptured among the basso-relievos of the Great Temple of Karnac prove it to have been in use in Egypt for above four thousand years.

The locks in use in the Faroe Islands, probably for centuries, are identical in their construction with the Egyptian, though lock and key are wholly of wood. They have been found in Egyptian catacombs, and a lock similar in character has been in use in Cornwall from time immemorial, which might have been introduced there by the Phenicians.

There are various allusions to a different kind of key used for fastening doors and gates, which was in the form of a large sickle. Homer says that Penelope, wishing to open a wardrobe, took "a brass key, very crooked, hafted with ivory." Eustathius says this kind of key was very ancient, and differed from those having several wards invented since, but it was still in use thirteen hundred years after Homer's time. It was shaped like a sickle and carried over the shoulder for convenience. It was probably inserted in a hole in the door, at some distance below a wooden bar, and then turned to the right or left, to remove it from the staple or replace it.

Homer's allusion to the lock on the wardrobe of Penelope is thus rendered by Pope:

"A brazen key she held, the handle turned
With steel and polished ivory adorned.
The bolt, obedient to the silken string,
Forsakes the staple as she pulls the ring;
The wards, respondent to the key, turn round,
The bars fly back, the flying valves resound,
Loud as a bull makes hill and valley ring,
So roared the lock when it released the spring."

Little can be gleaned of devices among ancient Greeks and Romans further than mention of bolts, bars, and locks. In the Odyssey, Ulysses is represented as securing the rich and costly robes, vases, gold, and other valuable presents of Alcinous and his queen by a cord or rope, fastened in a knot, "closed with Circaean art." This knot of Ulysses became a proverb to express any insolvable difficulty. The Gordian knot also has acquired lasting fame, and Homer describes the treasures kept in the citadel with no other protection than a cord intricately knotted.

Primitive locks for inner doors, unlike those of to-day, were not inserted or mortised into the doors, nor even attached, except by a chain, being, in fact, mere padlocks. Such was the celebrated Lacedemonian lock. We read of keys which had a ring the size of the little finger, to be worn, and engraved to be used as a seal. One is mentioned which has an onyx, engraved with the helm of a vessel between two ears of corn, in allusion, probably, to the occupation of the wearer, an importer of corn from the provinces, according to Pliny.

The Romans were not allowed except by special law to open a door outward, but two brothers who had distinguished themselves in war with the Sabines were granted this privilege of opening their doors to the street, after the Athenian manner. It was attended, however, with this inconvenience, when any one passed out, as he must strike the door vigorously from within, to warn any one approaching to keep his distance. In a garden at Pompeii was found a skeleton, with a key by its bony hand, and near it a bag of coins. Roman keys found in various parts of England are in the British Museum, and beautiful specimens of early English keys are preserved. Both these varieties belong to warded locks, but the shape of the cuts and holes in the "bits" of these keys proves conclusively that they did not perform a complete revolution, and therefore they were identical with the spring locks of modern days.

The elaborate and exquisitely finished English locks of an early period are very complex and are scarcely to be excelled in ingenuity of design or beauty of workmanship. Tradition says that locks were made in England in the reign of Alfred, but it was not till the fourteenth century that the craft was recognized as a distinct one. In the reign of Elizabeth locks with bells or chimes were so constructed as to ring an alarm or play a tune when they were tampered with. In the sixteenth century in Germany and France, as well as in England, the art of the locksmith was at its highest perfection, and the keys were truly artistic, with escutcheons, armorial insignia, ornaments and piercings upon the end to be grasped by the hand.

Warded locks were next in antiquity to the Egyptian pin locks, then tumblers followed. The tumbler is the lever or latch which falls into a notch of the bolt, and prevents it from being shot, until the tumbler has been raised or released by the action of the key. The tumbler must first be lifted by the key releasing the stump from the notch in the bolt, before the key can act on the latter to turn it either way. The period of its invention is unknown.

The most essential part of all is the bolt, which can be shot backward or forward, locked or unlocked, only by its own key, and the main point of security is, that the possibility of effecting this by other instruments shall depend entirely upon chance. Therefore the utmost pains are taken that the particular form of the key, or the requisite position of the parts for security, cannot be ascertained except by having possession of the original or true key, or by examination of the interior construction of each particular lock.

The first principle then is, to introduce wheels or wards about the keyholes, as fixed obstacles to pre-

vent anything other than the proper key from having access to the bolt. The second principle consists in the insertion of impediments to the retraction of the bolt. This idea appears in the Egyptian lock, but does not seem to have suggested itself to any inventor previous to 1778, when Barron improved on this ancient device and furnished added security by double-acting tumblers.

Brahmah's lock was patented in 1784, and subsequent patents were numerous. One patented in 1815 had a revolving curtain for closing the keyhole. Later one Gottleib secured paper over the keyhole to indicate tampering. At the present day the art of photography has been called into requisition as a detector. Thus we hear of a lock which is provided with a seal, which must be ruptured in the act of unfastening, which thus indicates the fact, if it has been improperly opened. Even should a fresh seal be introduced, it would be detected by a comparison with the photograph of the original.

It was thought that almost perfect security was attained in the improved warded locks, which were complicated and provided with numerous strong bolts. But by inserting a kind of blank key, covered with wax or soap on one side, a perfect impression of the wards was received, and a piece of wire was then bent in such a shape as to avoid contact with these when turned in the lock, withdrawing the bolt with perfect facility. This is a skeleton or master key.

Previous to the reign of James I. there is little or nothing on record regarding inventions of any kind, as there was no protection of patent laws, and every one kept the secret to himself to secure a monopoly for his personal benefit. Thus there is not a tittle of evidence to prove whether the warded lock was invented in England or introduced from some other country. There are representations of warded keys in early missals and other manuscripts since the commencement of the Christian era. Nothing can be more clumsy than the door locks in Turkey; but their mechanism to prevent picking is admirable. It is a curious thing to see wooden locks upon iron doors, particularly in Asia.

The puzzle or letter lock is one of the oldest in Europe, and attracted much attention two centuries ago. It is generally in the form of a padlock, opened and closed without a key of steel or iron, but by a mental one hidden away in the recesses of the memory of the person who closed it, the law of permutations contributing to the security. Some of these very curious contrivances consisted of broad steel rings, four, five or eight deep, upon each of which the alphabet was engraved; these turned on a cylinder of steel and only separated where the letters forming a particular word were in a straight line with one another. The word was selected from among a thousand, and the choice was the secret of the purchaser. Any one not knowing the word might turn the rings for years without finding the right one. In Beaumont and Fletcher's play of the "Noble Gentleman" we find the lines:

"A cap case for your linen and your plate,
With a stronge lock that opens with 'amen.'"

In the comedy of the "Heir" is the passage:

"As doth a lock
That goes with letters; for, till every one be known,
The lock's as fast, as if you had found none."

The French in their exposition of 1844 produced some marvelous locks upon the permutation principle. The Charivari said: "The proprietor of such a lock must have an excellent memory. Forget the letters and you are clearly shut out from your own house. For instance, a gentleman gets to his door with his family, after a country excursion, at eleven o'clock at night, in the midst of a perfect deluge of rain. He hunts out his alphabetical key and thrusts it into his alphabetical lock and says, 'a z b x.' The lock remains as firm as ever. 'Plague it!' says the worthy citizen, as the blinding rain drives in his eyes. He then recollects that that was his combination for the previous day. He scratches his head to facilitate the movement of his intellectual faculties, and makes a random guess, 'b c l o,' but he has no better success. In addition to his being well wet, his chances of hitting on the right combination are but small, seeing that the number is somewhere about three million five hundred and fifty-three thousand, five hundred and seventy-eight. Accordingly, when he comes to the three hundredth, he loses all patience, and begins to kick and batter the door; but a patrol of the national guard passes by, and the disturber of the streets is marched off to the watch house."

A puzzle lock of French manufacture and exquisite workmanship, having blued steel ends and shackle, and figures and symbols instead of letters, was sent to an English lock manufacturer about the year 1815 to be opened, as the combination was unknown. It belonged to the private baggage of Napoleon I., and the secret was probably known only to him. Numerous but fruitless attempts were made until the year 1856, when Mr. C. Aubin discovered the combination and unlocked it.

Prior to the Great Exhibition of 1851, more than ninety locks and contrivances in connection with them were patented, and there were at least seventy more whose improvements were not so protected. George Black secured a patent for a lock or latch so constructed as to raise the door over the carpet and admit air into the room without opening the door, yet nothing was added to security.

Barron's lock was a great advance in this direction, combining as it did the tumbler principle and the warded lock. Its simplicity and the strength of its internal mechanism have been points in its favor. Brahmah's lock has maintained its popularity from its ready adaptability to all cabinet purposes and the smallness of its key.

With the impulse given to mechanical arts by international exhibitions and the new emergencies and demands for other and still better means of securing personal property, "to make assurance doubly sure," till the culminating achievement of the time lock has been reached, among things inscrutable are the ignorance and indifference of the average individual upon the entire subject.

The difference between a cheap lock and an expensive one is rarely appreciated until the treasure is beyond recall. A safe is commonly supposed to be a place of security for money and papers, but whether constructed as a defense against burglars or a protection from fire may never occur to one, though a fire proof safe merely would readily disgorge its contents upon the application of an expert's methods.

The fact that mortar, or cement, or any one of the score or more of patent fire-resisting substances for filling costs less than the finest of steel and iron welded with all the strength and resistance possible to be produced causes many to purchase a receptacle which is really more of an aid than an obstacle to the plunderer, as the desirable things are presumably collected therein, and eight hours, so-called "burglar's time," in the night watches afford ample leisure for quiet operations without danger of disturbing a household, as would be the case if a thorough search were attempted in the different apartments.

A luckless traveler does not find his peace of mind promoted when a fellow passenger by mistake enters his stateroom by means of the key belonging to an adjoining one, and vainly speculates as to the number of persons on board who may by intention apply a similar key.

An absent-minded man, who finds himself in the occasional plight of being locked out of his own domicile by forgetfulness of his keys, reaches the comfortable fireside by borrowing, and from a handful finds several that will admit him, is thereafter haunted by a vague distrust of the protection he has hitherto believed in, and the query will arise, "Why may not entrance by another be effected at any time?"

The fact that a great demand for private safes or boxes in strong rooms has been noted seems to be indicative of a shaken faith in the ordinary places relied on for the safe keeping of articles of value small in bulk.

The number of people who habitually lock their doors, leaving the key in the lock, is by no means small, thus inviting the pincers of the burglar, who is greatly aided by the presence of the key. One who would spare no expense on jewelry, plate or wardrobe will be so careless about the means of protecting them as to be a marvel to the thoughtful, and surely culpable in presenting temptation to those who might not become wrong doers but for the easy access which prompts the experiment to open and pilfer and makes the confirmed criminal.

A locksmith, strange to say, has rarely, if ever, been known to be a burglar, though skill in picking might seem to justify the conclusion that such would be the tendency.

In these days of financial distress and commercial uncertainty, when men are tempted, perhaps, as never before, by dire necessities, and the social unrest, is it not a wise precaution to consider whether all has been done that common prudence might dictate to secure our homes from possible molestation?

SPECIAL SHOP TOOLS.*

To the President and Members of the American Railway Master Mechanics' Association:

Your committee on special shop tools, to report on new or improved appliances, either hand power, pneumatic, hydraulic or electric, applied or applicable to locomotive manufacture and repair, submit the following as the result of their investigation into this subject:

We find that while very few attempts have been made at utilizing electricity by our members as a motor or means of supplying power to special tools, they have nearly one and all recognized the great advantages derived from compressed air, an element that almost every one of them has right at hand, and that can be accumulated and conducted so easily, safely and cheaply.

Many have also taken advantage of hydraulics, and by simple and cheap methods have made plants of very considerable proportions with which much of their work heretofore accomplished at much expense for labor has been greatly cheapened and the length of time required to do certain work reduced over two-thirds; this is particularly applicable to heavy hoists and for drop pits in handling wheels under engines in roundhouse repairs, etc.

The experience gained by your committee in following their subject enables them to make some suggestions, which we hope may be kindly considered, and while most of our members, being familiar with, may have taken advantage of them already, there are no doubt large numbers who have not done so because their shops are small and means limited; and while standing more in need of cheap and simple means of getting out an increased amount of work than many others better provided, they hold back on account of small expense to be incurred or because they are afraid it will not pay in small shops and for other reasons, none of which your committee think will hold good.

We find much attention has been paid to the working of portable universal drilling and boring machines; they are, in fact, indispensable in the larger shops, and in any shop that handles even a few modern engines a month they can be made to pay largely. Some of our members have apparatus made by them, but there are on the markets several excellent portable drilling devices, some operated by power from the shop shafting, in shape of ropes, sheave pulleys, flexible shafts, etc., others driven by steam or compressed air. It is found that new locomotive cylinders can be drilled and reamed in the floor near where they are to be applied faster and more accurately with a good portable device than with most radial drill presses, and the heavy castings do not have to be moved as often as if under the drill press; all the heavy reaming for repairs, drilling out and renewing stay bolts, tapping stay bolt holes, and many other jobs formerly done by hand. The means of conveying power to these drilling machines can also be utilized for cylinder bores, valve seats, planers, etc., and where ropes and sheaves are used in connection with suitable snatch blocks or "turn-abouts" the power can be conveyed to any desired point. Your committee recommend their adoption as a labor and time saving device, and find that they are not as generally known and used as their merits demand.

Your committee were pleased to find that the use of convenient hoists is more general than they had reason to expect, yet they are by no means as well introduced as their merits as labor-saving devices demand. With safe and convenient appliances for hoisting work at lathes, planers, drill presses, etc., a large amount can be saved not only in handling and chucking, but the machines themselves can be kept going more steadily and the risk of accidents to employes greatly lessened. We find compressed air is being used by a large number of our members for this purpose in connection with pneumatic cylinders of their own construction, which can be gotten up cheaply in any shop. Others, by constructing suitable overhead ways, use differential or safety chain hoists to great advantage and get all the necessary movement for taking work from floor, swinging it into position for chucking and handling, frequently dispensing with a helper or laborer at the machines. We find that some of our members have cheap and convenient cranes at their larger machines, constructed in the shops at odd times, to which are attached either pneumatic or chain hoists by which work, heretofore very costly to handle, is easily placed in position. These hoists are also used in erecting shops and in the yards for loading and unloading, and in many larger plants compressed air is used for raising cars, in removing trucks, applying wheels, etc. We strongly recommend the introduction of cheap and reliable hoists for general use at heavy machine tools.

The possibilities of a good electric plant in connection with large locomotive and car shops are, in our opinion, very great; in addition to its use as motive power for cranes, transfer tables, turntables, etc., may be considered a means of lighting buildings and yards, welding, brazing, and perhaps other uses suggesting themselves as necessity occurs. A lack of familiarity with comparative cost of erecting and maintaining such plant, as compared with other and better known methods, prevents our touching further on this subject, and we leave it for the consideration of all interested.

Among special shop tools that are not very generally used, mostly because their value is greatly underestimated, or their better qualities little understood, are the best designs of patented small lathe tools. We refer to those tools so made, tempered and set in stocks or holders as to prevent the necessity of dressing and shaping, but that always present a proper cutting edge by grinding the dulled point only. Such tools are cheap compared to the immense quantities of high-priced tool steel cut up monthly for small lathes. The small tool departments of a few of the best special tool makers can give some interesting information in regard to such tools, and no doubt some of our members can. We are aware that the market contains a number of them that are almost worthless; but there are good ones at hand.

Another class of shop tools that can be gotten up in any shop, but which we find are not generally in use, are the holding bars, or stocks, made to fit tool posts of large engine lathes, and even wheel lathes, as well as planers, slotters, etc., and so arranged with suitable slots and set screws for taking short bits or tools of square tool steel of proper size for work in hand; in this way the very best quality of tool steel may be used at a small cost, and the tools are more handy and can be kept in better shape with less work than if dressed on large pieces of heavy steel. A tool holder of this kind is used to great advantage in upright slotting machines, and can be provided with clearance for the upstroke by simple spring arrangement, thus saving the cutting tool from being broken or worn on point.

We find the matter of convenient and accurate lathe mandrels has not received the attention it should in most repair shops, and instead of the gradual introduction of good "expanding" mandrels, a majority of shops are still depending on the old solid mandrel in its most temporary form, and some shops have a ton of them which if put up at their actual cost would purchase a full set of the best expanding mandrels, and if sold for No. 1 wrought scrap, would go far toward the cost of enough of them to take the place of about all their old mandrels.

Your committee have decided to mention the Nicholson expanding lathe mandrel as probably the best of which they have knowledge, and as having been mentioned by all members who touched on this subject in their contributions to the committee work.

We desire to impress upon our members the advantages to be obtained in looking carefully around and corresponding with fellow members when they are selecting shop tools with a view of getting what are really "special shop tools." Among the most useful of the special tools above mentioned, we would suggest that the possibilities of well designed heavy turret lathes and heavy universal milling machines and punching machines, designed to meet the requirements of heavy locomotive shop repairs, make them the most important special machine tools to be considered in equipping a shop. We mention the punching machine particularly, from the fact that we find it is not as generally used as it should be in repair shops.

The rapid introduction of self or air hardening tool steel has caused the retirement of the old style grindstone as a means of sharpening large machine tool cutters, etc., and the substitution of heavy tannite and emery grinders has proved wherever tried a paying investment; those styles of grinders designed to use water plentifully on the wheel have shown their superiority over the dry wheels.

In conclusion, your committee want to forcibly impress each member with the importance of a "tool room" and tool keeper. In our opinion, no shop, however small, can afford to be without a tool room, if it is nothing but a corner railed off in the shop and looked after by the foreman.

T. W. GENTRY, GEO. L. POTTER,
H. D. GORDON, G. R. JOUGHINS,
WM. SWANSTON, F. B. MILES,
Committee.

* From a report presented to the Master Mechanics' Association.

EVERY railway traveller of a scientific or investigative turn can tell you queer stories of how the rails "creep," but the greatest scientists of the world do not attempt to explain the phenomenon. It has been known for years that rails do "creep," but it has only lately been learned that on lines running north and south the west rail "creeps" faster than the east.

[Continued from SUPPLEMENT, No. 972, page 15532.]

THE MANUFACTURE OF SMOKELESS POWDER.*

By OSCAR GUTTMANN, Assoc. M. Inst. C.E., F.I.C.

PROFESSOR C. E. MUNROE proposes for his smokeless powder, which he calls Indurite, to use very pure guncotton, which he obtains by treating the ordinary guncotton in a kind of extracting apparatus with repeated infusions of methylic alcohol, until all the soluble nitrocellulose is eliminated. The remaining hexanitrocellulose is dissolved in nitrobenzine. He then rolls the mass out into sheets and cuts it into grains, and the resulting rather soft flakes are treated with hot water and steam, as is the case with the Walsrode powder, whereby the grains harden externally. He calls this latter process the induration. I believe that as nitrobenzine is highly volatile at comparatively low temperatures, all that takes place in this induration is simply a partial evaporation of nitrobenzine on the surface, which has the effect of leaving the guncotton bare and hard.

The Dupont powder, in which nitrobenzine and nitrocellulose also enter into combination, is made by a somewhat similar process to that of Lundholm and Sayers. The only difference is that a special apparatus with rotating paddles is used, whereby the mass is first made into a dough, and then on continued stirring, breaks up into grains. By admitting steam into the apparatus the grains, which at first have a soft, putty-like appearance, become hard and consistent. When the grains are finished, they are placed in a rotating barrel, into which steam and water are admitted. This has the effect of making the grains round, and carrying away any excess of solvent.

The French Poudre Pyroxylée is produced by a rather complicated process. The materials are first mixed by hand, and then in incorporating mills for 45 minutes, where an addition of 40 per cent. of water is made. After this, they are rubbed through a sieve of about 1/16 of an inch mesh, dried up to 1 per cent. of moisture, and 65 per cent. of ether added to the mixture. The putty so obtained is rubbed through a perforated zinc sieve with holes about 1/16 of an inch diameter. The mixture of grains and dust thus produced is revolved in a wooden drum for 45 minutes, then moistened with 50 per cent. of water and afterward dried. The grains are sorted, those between 1·6 and 1 mm. diameter being moistened with 15 per cent. of ether and polished in a copper drum. The powder is then again rubbed through a sieve of about 1/16 inch mesh, and again sorted into grains between 1·6 and 1 mm. The residue is treated in a similar way in order to again get grains of suitable size, and the final powder consists of one part of grains of the original make and two parts of those coming from the working up of the residue. The Poudre J is probably made in a similar way.

The properties of smokeless powders vary very much, according to the composition, the mode of manufacture, and also according to the object for which they are to be used. For large guns, a powder is required which burns very slowly, in order that the force should be developed gradually, so that the energy imparted to the projectile should reach its maximum as the projectile is just about to leave the gun. For sporting powders, on the other hand, a quick combustion is desirable, in order to impart to the shot sufficient penetration and little spreading, or what is called a good pattern. At the same time, the powder should develop as small a gas pressure as possible and a very high muzzle velocity. For military purposes it is desirable that there should be as much force as possible given off by unit weight of the powder, because this enables rifles of small caliber to be used, and it also allows the soldier to carry a large number of cartridges. For sporting powder, on the other hand, it is not possible to change the type of the guns in use as rapidly as it can be done by the aid of a national exchequer with service rifles, and the sportsman prefers a powder that he can use in the same cartridge as black powder. Considering, then, that an average charge of black powder for a 0·500 express rifle is about 138 grains of Curtis & Harvey's No. 6 black powder, whereas of a good smokeless powder only 47 grains are needed, it is easy to see that with the smokeless powders a large space of the cartridge will remain empty, although the volumetric density of the smokeless powder is much smaller than that of black powder. For sporting purposes, therefore, such a powder whose volumetric density is the smallest, and which is consequently most likely to fill the whole of the cartridge case, possesses some advantage.

This brings forward another question which has for some time given a good deal of trouble with smokeless powders, namely, the loading of cartridges. With black powder, a slight increase of the charge meant much less than with smokeless powders. The latter are very liable to set up extraordinary pressures when the charge increases, and with some of them it has been found impossible to take more than 1½ times the charge, for fear of bursting the gun. On account of the flaky nature of some of the powders, the ordinary machines for loading cartridges, where the powder runs through a funnel in a measured vessel, could not well be used, because the powder settles differently, and occasionally there is an increase in the weight of as much as 10 per cent. These obstacles have, however, been overcome with most of the powders.

One of the peculiarities of a small bore rifle is, that the smaller the diameter of the projectile becomes, the straighter will the flight of the shot be, because of the diminution of the air resistance. This, of course, has led to the adoption of very long projectiles, and in judging a powder, the straightness of course of the projectile will have to be considered. An idea of the diminution of the height of flight can be gathered from Fig. 8, in which there are represented the path of projectiles from the old Prussian 13 mm. needle gun of 1862, the French 11 mm. Gras rifle of 1874, and the 6·5 mm. Mannlicher rifle of 1892. It will be seen that a man of average height, say 1·6 m., or about 5 ft. 3 in., is liable to be hit at any distance up to 295 m. only with a needle gun, up to 375 m. with a Gras rifle, and up to 590 m. with the Mannlicher rifle. There is a corresponding increase for lower-lying objects, as will be seen by the plain and lined parts of the diagram, which represent objects of 0·4 and 0·8 m. height.

The absence of smoke in a powder has become a great consideration now, but it can be said that almost every smokeless powder produces only steam and gas without color. The sole difference is to be found in the constitution of the gas, which in some powders may contain free nitrous acid, whereas with others, a perfect combustion takes place. At one time it was thought that armies could not long stand the fire of smokeless powder on a battle field, because of the penetrating "chemical" smell evolved, but this has been almost entirely overcome now. The marked difference in the color of the products of combustion from ordinary black powder and those from the new smokeless powders I shall endeavor to show to you by a method suggested by my assistant, Mr. Pollitt. It consists in burning small portions of the various powders on a tray and throwing shadows of their products of combustion onto a lantern screen.

Very important is the question of residue and heat developed. Some powders only leave a slightly imperceptible residue which is cleaned out automatically by the next shot. The heat evolved in connection with the friction caused by the residue erodes the rifling of the gun, and how delicate a mechanism rifling is, will be understood when I say that the depth of the rifling in the Lee Metford rifle is only 0·004 in.

A good powder should furthermore be perfectly stable under varying temperatures and should not suffer by storage in moist climates or damp stores. At the same time it is highly desirable that the powder should not be liable to explosion when struck by bullets, and that loaded cartridges should not explode "en masse" when carried in an ammunition cart.

From all this it will be seen that the manufacture of a good smokeless powder requires a large amount of skill and experience, and that however well devised the composition of a powder may be, it is liable to be unsuitable on account of its not fulfilling one or the other of the numerous conditions imposed upon it.

The form of smokeless powder now used is either that of grains, small flakes, cubes, or of cords. The grains vary in size. In grained powders there are between two and three thousand grains per gramme. The flakes for military purposes are 1½ m. square and 0·3 mm. thick. For sporting powder the thickness is reduced to 0·1 mm. The thinner the powder flakes are, the quicker they will burn. For large guns the flakes are made 3 mm. square by 0·7 mm. and upward, or they are made in cubes of 2, 5, 10, and 15 mm. side.

Cordite and Filite are made in various thicknesses. That for the service rifle is 3/80 (0·0375) in. thick, and its diameter increases with the size of the gun for which it is used.

Fig. 8.

The color of smokeless powder is, as a rule, in consequence of the action of the solvent, rather a dirty gray or yellow; with nitroglycerine powders, from light to dark brown. Very often the powders are polished with black lead in order to fill up the pores and to give them a smooth surface, in which case, they have a silvery gray or black appearance.

The absorption of moisture by a good smokeless powder is very small, and if it should become damp, it can be easily dried again. An experiment made by exposing Ballistite in open saucers for a whole year has shown that most of the powders contained less moisture at the end than before exposure.

The volumetric density of smokeless powders varies between 0·55 and 0·40. The absolute specific gravity is about 1·60 for most of them.

In this country and in most others, smokeless powders are tested for their stability against heat in a similar way to guncotton. But they are also tested as to the increase of gas pressure resulting from an increase of temperature in the barrel. According to an experiment made by Sir Andrew Nobel with a 4·7 in. quick-firing gun, Ballistite developed a mean pressure of 14·3 tons per square in., or 2,180 atmospheres. Cordite, 14·3 tons per square in., or 2,127 atmospheres, whereas the ordinary service pebble powder gave rise to 15·9 tons per square in., or 2,024 atmospheres. The muzzle velocity was 2,140 ft. seconds for Ballistite; 2,140 ft. seconds for the Cordite, and 1,839 ft. seconds for the pebble powder.

Smokeless powders are, as a rule, not explosive in the ordinary sense of the word. They burn with some difficulty and they are also fairly insensible to blows or the impact of bullets. The consequence is that they require caps of great strength, and developing much heat. They generally give off permanent gases, mostly carbonic acid and steam, but there are also some nitro-oxygen gases formed, which impart a slight yellow tinge and a little pungent smell to the smoke. On account of these acid compounds developed, there are always traces of acid residue left in the barrel, and unless these are cleaned out after ceasing to fire, the barrel becomes rusty.

The chemical analysis of smokeless powders is on similar lines as that of blasting gelatine, but it is necessary to grind them in a mill in order to reduce the very hard grains to a fine powder. This grinding sometimes causes particles of iron and steel to fall into the ground powder, which have to be taken out by means of a magnet.

What I have said here must of necessity have been of a somewhat superficial character, because, on the one hand, the various governments and manufacturers do not as a rule willingly divulge the details of their manufacture, and the knowledge to be acquired is therefore somewhat circumstantial. It is thus quite possible that not everything I told you is absolutely accurate, yet I have given you what I believe to be correct. Of course, I have not said all I could say on the subject, because this is not desirable for various reasons. All I wanted to do was to give you a general idea, to show how smokeless powders are constituted and made, and to enable you to follow this question a little more closely in the future. One thing I wish to impress upon you is, that with a comparatively new manufacture dating back only six years, it is quite impossible to have acquired all the experience necessary for the production of a powder faultless in every respect. There must, therefore, be of necessity a number of complaints at the beginning, and a large number of defects have been found in each powder in each country. In this empire especially, which extends almost from the north pole to the south pole, where there are extreme varieties of climate, temperature, and moisture, the manufacture of a powder fully up to the requirements of the service is extremely difficult, yet up to the present it has been found possible to meet most of those defects as they showed themselves in course of time, and I have no doubt that, if the necessity for any further improvements becomes evident, it will be quite possible to effect them.

DISCUSSION.

Mr. W. F. Reid said that the whole manufacture of powder for the army had become a chemical process, and on listening to the formulæ that had been mentioned, they were almost transported into the benzine ring. With regard to Schultze's powder not being adapted to military purposes, that was partly due to the nature of the ash. Both that and the E.C. powder left a hard ash, while ordinary black powder left an ash to a certain extent soft, which afforded some lubrication to the succeeding bullets. With a hard ash the rifling was soon obstructed, the bullets stripped, and all accuracy was lost. The author had referred to him in connection the E.C. powder, which he described as being the first powder which, if not quite smokeless, yet approached that condition, and also to his having been the first to harden the grain, by means of the action of a solvent upon the guncotton contained in the grain. That was the theory he had before him in working at that powder. Mr. Guttmann said it was a pity he stopped at that stage, but as a matter of fact, he did not stop there, for he made a number of further experiments on guncotton powders, but there was a very good reason for not issuing them at that time. The use of powder for sporting guns was limited entirely to the cartridges then in use, as it still was practically, and for military purposes it was quite impossible then, and still was, for any English inventor to introduce any powder into the army in this country. The usual way was to bring them before a foreign government, and then that acted on public opinion, public opinion acted on the government, and then something was done. That was the case with the smokeless powder. In 1882 he had occasion to show some French military attaches some of those experiments, and two years afterward they were in full swing, experimenting on the same subject in France.

The English government took somewhat longer to get to work upon the subject. In 1882 he took some specimens of smokeless powder to Waltham Abbey, and they were tried, and two points in particular were raised as being great objections, though there were others also; one was that the trajectory was so much flatter that the sights of all the rifles would have to be altered. Another was that the amount of powder which could be concentrated in a given space would necessitate an alteration in the cartridges; this would involve an alteration in the whole of the rifles, and of course nothing was done. Then when the French government took up smokeless powders, the question was brought in a very prominent way before Parliament, and before the military authorities.

One of the most important points in the manufacture of smokeless powders alluded to in the paper was the alleged impossibility of recovering the solvent economically, and it was said that hitherto that had not been done on a large scale. It was done on the commercial scale with the E. C. powder, in fact it was one of the first questions which occupied his attention. The solvent, which was a composition of ether-alcohol, was very expensive, and a great number of experiments were made with the object of recovering it. This was finally done in a simple manner. The apparatus consisted of a revolving drum heated externally, and a current of warm air passed through it. A very slight current was necessary, and then the air containing the solvent was cooled down, and the solvent recovered, the greater portion of it, at any rate. That could be redistilled, and used over again.

As a matter of fact, this point was of great commercial importance in the manufacture of these powders, and he had no doubt that in most cases the solvent used could be recovered at a nominal cost. With regard to acetone, there was a good opening for any member of the Society who could find some means of producing it cheaply. At present it was a very expensive substance, but the demand for it was increasing rapidly. Theoretically, it was possible to produce it from a variety of substances, such as sugar, and he had made some experiments in that direction, but it was not a practical process at present. He was quite sure there was a great future for chemical industry in that direction. Another point which he did not think had been sufficiently emphasized in the paper, though it must have impressed itself upon all who were present, was the great safety with which these powders could be handled. As a matter of fact, they were extremely safe. If the largest cube on the table were set fire to, it would not burn more violently than a small quantity of, say, petroleum, and it would not explode as black powder did. That was of great importance in handling these explosives.

With regard to the general use of these powders, so far as his present knowledge went, those which con-

* Read before the London section of the Society of Chemical Industry, May 21, 1894.—From the Journal.

tained nitroglycerine were being rapidly superseded by those which consisted of nitrocellulose alone. So far smokeless powders have proved successful, and, as the author had remarked, they had reached a certain stage, but they hoped to do better. He thought the process of the survival of the fittest would result in the use of nitrocellulose alone. With regard to the lengthening of the projectile, it was only possible to elongate it and to diminish the diameter within certain limits. Beyond a certain point such an amount of friction was produced in the rifle that the pressures became too great, and there were other theoretical reasons with regard to the flight of the projectile which prevented elongation beyond a certain extent.

He believed also that doctors rather objected to a long, narrow projectile. He heard of one military surgeon having stated that it was like sending a knitting needle through a man; it did not disable him at the moment, but it was a very difficult wound to cure. These small bore bullets would also go through about a dozen men, one after the other. The amount of smoke developed could not be quite gauged by the appearance when the powders were ignited in open space; it was much less when ignited in a confined space, because substances which in the open air were condensed in the atmosphere as soon as they touched cooler air, became volatilized in a hot confined chamber, and did not show. These powders had a great advantage over the old black powders in respect of storage. They could be stored under water, and when taken up and dried were as efficient as ever.

In 1882 he sent a sample of E C. powder to a yachtsman who was out wild fowl shooting. His boat sank, and he related with great enthusiasm that he got up the powder, boiled it and then baked it, and it was much better than it was before; he even advised baking all his powder, because he said he got so much better force with it. That showed the great advantages which modern military men had, that they need no longer keep their powder dry, according to the old Cromwellian maxim. The climax of propulsive power, he thought, had almost been reached with smokeless powders. Theoretically, the maximum effect would be produced if one could get solid hydrogen in connection with solid oxygen and detonate them together.

At the point which had now been reached they were obliged to take in some inert nitrogen also, but if they could eliminate the nitrogen and leave the other substances in a state so that they could at once be converted into gas, of course matters would be improved, but theoretically he did not think there were any much greater advances possible in this direction. The progress which would yet be made no doubt was probably in their shape or the form of the grain. One method of propulsion, though one could hardly call it a smokeless powder, was that by means of liquefied or concentrated gas, and some experiments were made not long ago by M. Giffard which were not quite successful from a practical point of view, but they showed a way in which progress might in future be made. The method of cutting up the sheets of nitrocellulose after they had been hardened to form a powder was, he thought, open to very grave objection theoretically. If you could get a globular form of grain, you would certainly have a better powder theoretically in every way. With flat grains there was the disadvantage of their setting or caking together, and you could never be quite sure that you had exactly the same spaces between the grains. Next to the globular form, no doubt the cylindrical was the best, but that also had a disadvantage from the point of view of ignition. On the question of ignition again the caps were of very great importance, and in this respect these powders were very different from the ordinary black powders. They required a certain definite amount of ignition to produce a definite effect, and unless the caps were very regular you got irregular results with powder of exactly the same composition, and used in the same quantity. He discovered that in a very startling way by some foreign cases containing very strong caps which were introduced for nitro-compounds for sporting purposes. The result was a number of burst guns and accidents to sportsmen.

It was very important that the method of ignition should be uniform, and in the ordinary caps this was not so. With regard to the manufacture of these powders, unfortunately as they had seen recently in the government factories many accidents had happened, but it was rather curious that those accidents did not happen to such an extent in the private factories. There were many things which caused danger in a new explosive of this kind, and he might mention one which he found himself of very great importance, and in erecting smokeless powder factories he had always provided for it. That was electricity. One effect of covering the grains with graphite or plumbago was that it formed a conducting surface. If you shook these nitrocellulose sheets together, if they were not blackleaded, they became highly electric and adhered to each other and to everything. In fact, they would often adhere to your fingers after having shaken them up for a bit. If they were faced with graphite, that did not happen. Now in the government factories it was the rule to exclude all metal from the interior of the drying sheds. But you were bound to have metal in some form in the shape of pipes and fittings, and if you covered these, which was often done, what you really produced was a Leyden jar, which became charged with electricity in a warm house when the powder was moved or a current of air set in motion, in fact such a drying house was frequently a laden Leyden jar, and a spark might be produced which might cause a serious accident. The practice he followed was always to have metallic connection everywhere. Even in the treatment of dry nitroglycerine a considerable quantity of electricity was produced, which he had been able to detect.

Mr. W. P. Bloxam said the author had not made any reference to the use of smokeless powder in her Majesty's navy, which he thought was a slight oversight, as they were greatly interested at present in the issue of this smokeless powder and its stability. Of course it would be very difficult to obtain any official utterances a to the stability of Cordite and such like materials after exposure to high temperatures, but there was very distinct evidence of the high temperature of the magazines in many modern warships, and the seamen gunners and the gunnery officers were considerably exercised in their minds as to what would be the effect of the prolonged storage of Cordite in the magazines of some of these ships. Again, if he followed the paper correctly, the author did not refer to carbon monoxide, but he believed from certain statements that there was as much as 38 per cent. of carbon monoxide recognized in the products of combustion, and the seaman gunner again was not looking forward with any great pleasure to the use in closed turrets of a material which developed such a quantity of this gas.

Comparatively little, from a physiological point of view, was known of the toxic effect of this gas, but it was stated variously that from 0·1 to 1 per cent. proved rapidly fatal. He wished to know, therefore, if they were likely to have 38 per cent. It was very difficult, as Mr. Guttmann said, to get much information. They could not expect the powder to grow up in six years and do everything it ought to do, and they must not be impatient in trying to force the hands of those gentlemen who were carrying on patient researches toward perfection; but still, though the sailor was a confident man, he would not swallow everything. It was not so much a question of the strength of poor Jack as the persistent nature of carbon monoxide. Of course everything could not be stated in so short a period, but he was bound to say, being associated with naval gunnery officers, that it was of great importance to hear such an able and concise summary classification of smokeless powders so lucidly presented.

Mr. W. Macnab said he only had one or two remarks to make, not so much on the manufacture of smokeless powder as on one or two points which had been raised incidentally. With regard to the explosive Rifleite, he said that he had never found any alkaline or alkaline earthy nitrates in specimens he had examined, the components being nitrocellulose and nitrobenzine. With regard to the production of thick sheets of smokeless powder, no doubt it was quite correct when made with acetone or similar solvents, in order to make a thick sheet, to run several thinner sheets together; but in making the ordinary Ballistite, consisting of nitroglycerine and nitrocellulose, in which no facilitating solvent is used, the sheets could be readily rolled up to about 1¼ inches at once. With regard to what the last speaker said about the gas produced by the explosion, he could entirely confirm his opinion that there was carbon monoxide produced from Cordite, Ballistite, or, in fact, from nitrocellulose powders, to a large extent, sometimes amounting to 30 per cent. or 40 per cent. of the permanent gas. The more nitroglycerine there was present the less was the percentage of carbonic oxide and the larger the percentage of the less harmful carbonic acid. One point which might be of some little interest was with regard to the effect of gelatinization on nitrocellulose. He had examined nitrocellulose (guncotton) as to the amount of heat evolved on explosion by a good sample of it containing 13·30 per cent. of nitrogen, and the result was that 1,061 calories were developed, but the same after gelatinization, and being cut into grains, yielded 922.

Mr. Guttmann, in reply, said Mr. Reid said that the Schultze and E.C. powder gave a very hard ash, which was one of the chief reasons they could not be used for military purposes. No doubt that was one reason, but there was also the other reason that he gave in the paper, that they could not be made of such a degree of uniformity as to fulfill the very strict requirements of military purposes. As to the recovery of the solvent, he simply stated that it was found impossible to recover it economically. Mr. Reid told them that they tried to do so in a revolving drum, passing heated air through it, then collecting the gas and condensing it. That was precisely the way in which it was tried by various governments, and in various countries, but found impracticable, for the simple reason that when you had to deal with very large quantities, much larger than the E.C Company had, you wanted such a large amount of drying drums and such a large quantity of air to pass over the powder in order to evaporate the solvent perfectly and absolutely that the amount of acetone contained in the air was too small to be worth recovering. This, at least, was the experience of various governments with which he was acquainted. Mr. Reid also said that there would be a good opening for a chemist to produce acetone cheaply. He believed there would be some opening, although he believed the quantities that were used by each government were much smaller than was generally supposed. Still a good deal of saving might be effected in that direction, and as a matter of fact he (Mr. Guttmann) had erected an acetone plant for the government at Waltham Abbey. With regard to powders containing nitroglycerine being rapidly superseded by those containing only nitrocellulose, as he had said in his paper, he did not wish to express any opinion as to the merits of the various powders. He believed it would be wiser to abstain from so doing. Everybody had a right to his own opinion, and Mr. Reid would allow him to have his. Then Mr. Reid said the projectiles could not be elongated beyond a certain point, which was quite right.

He only said that with the smaller bore the projectiles had to be lengthened. To what extent that was possible was rather a question for military men; still it had been found that a rifle with five mm. bore, or about 0·2 of an inch, was quite practicable. It had been tried, and it was quite on the cards that it might be introduced somewhere. As far as the rifling of such a small bore went, there was no difficulty in making even so fine a rifling as required for that. Mr. Reid was not quite right when he said the wound produced by such a small projectile was so small that a man might go on fighting and then afterward find himself incapacitated. Experiments had been made with small bore bullets for a very long time, and a very elaborate work on the subject had been issued by the firm of Lorenz, of Carlsruhe, who first made compound bullets. Quite recently, in Austria, he was sorry to say, there had been riots, and the small arm rifle had played havoc with some of the miners, and when examined it was found that the bones were shattered more than with a large bore. They made almost incurable wounds. With regard to the amount of smoke developed, what Mr. Reid stated held good to a certain extent only.

There were certain products of combustion which if you burned a powder in the open air would simply escape by force of the combustion, that is to say, solid particles not being burned, and that would not take place in a confined space to such extent; but when you burned a small quantity of powder which flashed up in a comparatively long time when there was plenty of time for combustion to take place, the difference between the smoke as regarded a confined and unconfined space was not so very large. The use of liquefied gas for the propulsion of bullets had been mentioned, and the experiments of M. Giffard of the sliding railway fame in the Paris Exhibition. He believed both M. Giffard and Mr. Edison, who wanted to decompose water and form gas and explode it, were on the wrong tack as far as practicability went. He quite agreed that theoretically the combustion of solid oxygen and hydrogen were probably the best things in the world, but to introduce them into practice required a genius, and he feared that manufacturers were not always geniuses. Then it was said that globular powder was better than flat powder, especially that flat powders caked together, and the flame could not be propagated so fast. He had no interest in advocating either one or the other, but all he could say was that he had on the table samples of smokeless powder of various descriptions, and every one examining Von Forster's powder would find that it consisted of a peculiar form of flakes which made them fill up an ordinary black cartridge, although the weight was only one-third, and there was plenty of air space and probably more than with globes. With a globular grain, if you made it small, you would have plenty of surface in relation to bulk; but if you had it too great the bulk would be much larger than the surface presented, and this might not be the case in the flake powder. For large powder like Ballistite it would be impossible to make globular powder of that size.

Globular powder might have its advantages as against cubical powder, but it would take too long to go into full explanation of these details; it would be sufficient to say that those who selected cubical powder had very good reasons for their choice; those who selected flakes and those who selected the globular had also a reason for what they did. Every one tried to work in the right direction, and, as Mr. Reid said, in the result the fittest would be found to survive. With Von Forster's smokeless powder a peculiar mode of drying was adopted, which caused the flakes to crumple up, and consequently leave a great amount of air space. Reference had been made to the accidents at Waltham Abbey, and it was said that such accidents did not happen at private shops. He was happy to say that he had not yet had a serious accident in his 20 years' experience, but he believed he was an exception. He was sorry to say that most of the manufacturers had found in starting their works, and in the beginning, when they did not quite know how to work or exactly the nature of the stuff with which they were working, that there were sometimes explosions. Not so very long ago there was a very severe conflagration, not an explosion, in a Ballistite factory in Italy, and there had been a number of accidents in connection with nitroglycerine all over the world, although much less than in gunpowder works, so that they need not be surprised that there had been some at Waltham Abbey. There must always be some experiments made, but he believed they could be done with proper care. He could not speak any further on that subject, as he might have to give evidence on the subject.

But he thought it would be found eventually that the explosions at Waltham Abbey, except the last one, were not of such a serious character as was thought. With regard to electricity in connection with nitrocellulose powder, Mr. Reid would remember that he dealt with that very fully in a paper before this society last year, where he acknowledged his work in construction of drying houses so as to make them nonelectric. He did not think the black-leading of nitrocellulose was done with that object generally, though it had that effect; and he quite agreed with Mr. Reid that the electricity should be carried away with such powders. Unfortunately every manufacturer did not see it in that light, and he feared they would have many guncotton drying houses on fire before they realized the importance of this matter. The black-leading was generally done for the purpose of filling up the pores of the powder and giving a smooth surface. Mr. Bloxam had found fault with him for not mentioning powder for the navy, but as a matter of fact he did not know of any general difference between powder for the navy and powder for the army, for the same effect was desired, the same class of powder would be used, and the exigencies for all of them were nearly the same.

With reference to the high temperature of the magazines, he thought he recollected seeing in some paper a letter asking why did the constructors of ships set their magazines so near the boilers so as to overheat them; surely they might put them somewhere else, and if for other reasons a powder is preferred which does not stand heat so well as black powder, the removal of the magazine was not an insurmountable difficulty. Then there was an answer to that, of course, that they could not alter the ships, the magazine was in the most handy place, and so forth, but even then there were means known by which such magazines could be cooled down if necessary. But in general the danger of overheating such powder was not so great as people imagined. It would stand a good deal of heat before it decomposed or went off. Mr. Macnab had corrected him with regard to Rifleite not containing potassium nitrate. He also said Ballistite could be made in sheets up to 1¼ in. in thickness. No doubt it could; he believed it might be made thicker, but he did not believe they would be good sheets or that they would work well in a gun. In making such thick sheets the difficulty of removing the air bubbles and the solvent would be very considerable.

Mr. W. Macnab said he referred to powder made with nitroglycerine.

Mr. Guttmann said he understood that, but even with these the air bubbles would remain. Mr. Macnab had answered Mr. Bloxam with regard to carbon monoxide, and therefore he need not say much with regard to it. There would be carbon monoxide wherever there was imperfect combustion, but their aim was to make a powder which had perfect combustion; Ballistite, Cordite and nitroglycerine powders in general gave perfect combustion, provided they were properly made. Nitroglycerine having an excess of oxygen in burning would always produce gases containing less carbon monoxide than others. His remarks as to heating, and so forth, were highly interesting, and he understood Mr. Macnab had done a great deal to investigate the heat developed by various powders.

THE NEW TOWER BRIDGE, LONDON.

JUNE 30, 1894, was a gala day in London, the occasion being the opening of a new bridge over the Thames River, located near the Tower. No ceremony is considered of any consequence in England unless the Queen or her representatives take a conspicuous part therein. On this occasion Her Majesty was represented by the Prince of Wales and a galaxy of princesses, princes, dukes, duchesses, and other notables.

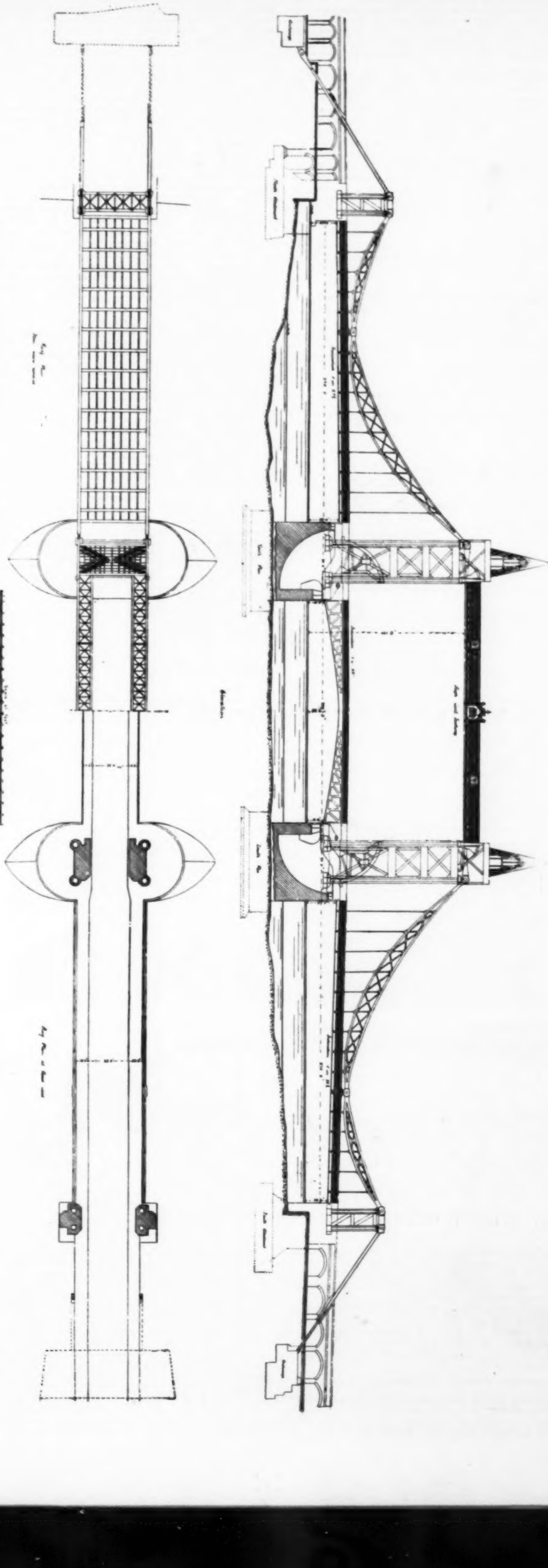
There was a grand procession, then addresses, the Prince touched an electric key, which caused the draw to operate, and then declared the bridge opened; the Bishop of London pronounced a blessing, and a royal salute followed. A procession of gayly decorated steamboats passed through the draw, the Prince gave a reception on the bridge, the royal party embarked on a steamer and landed at Westminster Bridge, thence home in carriages. We are indebted to Black and White for our two photographic views.

The act authorizing the work was passed in 1885, and the foundation stone was laid by the Prince of Wales June 21, 1886. As a whole, it is a heavy piece of work, occupying much more valuable space than was necessary. But it was considered by those who had the say that such a work, located as it was, near the historical Tower of London, ought to be massive, and present a mediæval architectural look. So they sank a pair of great piers in the narrow river, erected strong steel frames thereon to carry the cables and other parts, and then clothed the steel work with a shell of stone, the work, as a whole, being thus made to represent a structure of massive masonry.

The London Builder denounces the work as a case of false pretenses. But there is no denying that the

THE NEW TOWER BRIDGE, LONDON—THE BASCULES CLOSED.

THE NEW TOWER BRIDGE, LONDON—THE BASCULES OPEN.



THE TOWER BRIDGE, LONDON—GENERAL ELEVATION AND PLAN OF THE CONSTRUCTIVE IRON WORK.

bridge looks well, and makes a solid, grand, and substantial appearance.

The construction is peculiar. The draw consists of two leaves called bascules, which open vertically to allow the passage of vessels. These bascules are weighted at their lower ends and turn easily on pivots arranged in the bases of the towers. The width of their span is 200 feet. Between the towers, at their upper ends and 140 feet above high water level, extends a permanent bridge for the use of foot passengers. There are elevators in the towers to take up the passengers, so that when the draw is opened foot passengers may still use the upper bridge. It requires five minutes to open and close the draw and allow a vessel to pass. The bascules are operated by pinions that engage quadrants on the lower ends of the bascules. The entrance to the bridge on the Middlesex side is opposite to the Mint. The approach passes along the east side of the Tower to the shore, where the northern abutment is placed on the west side of the wharf belonging to the General Steam Navigation Company. The south abutment is placed a little to the westward of Horselydown Stairs, and the approach on this side of the river is about 800 feet long, and runs in a straight line from this point, on a falling gradient of 1 in 40, until it meets Tooley Street. The north and south river piers are similar in all respects, and are we believe, the largest of their kind in the world, the area of the two piers at the level of the foundations being about equal to the whole of the twelve circular piers carrying the Forth Bridge. The only other foundations of such dimensions are those of the Brooklyn Bridge, the two main piers of which support a roadway of 1,606 feet span. The total length of the bridge, including both approaches, is just half a mile. The total height of the towers on the piers, measured from the level of the foundations, is 293 feet. For the construction of this bridge some 235,000 cubic feet of granite and other stone, 20,000 tons of cement, 70,000 cubic yards of concrete, 31,000,000 bricks, and 14,000 tons of iron and steel have been used.

The mode adopted for spanning the landward openings is the suspension system—that is, by stiffened chains anchored in the ground at each end of the bridge, and united by a horizontal tie across the central opening at the high level. This tie is carried by two narrow bridges ten feet in width, forming foot bridges, which come into use when the opening span is open for the passage of vessels. Above the landings from which the foot bridges start, and on which the foot passengers land from the lifts, come the roofs of the towers, the tops of which are 162 feet above the roadway level, or 264 feet from the bottom of the foundations.

The bridge has cost the enormous sum of $5,500,000.

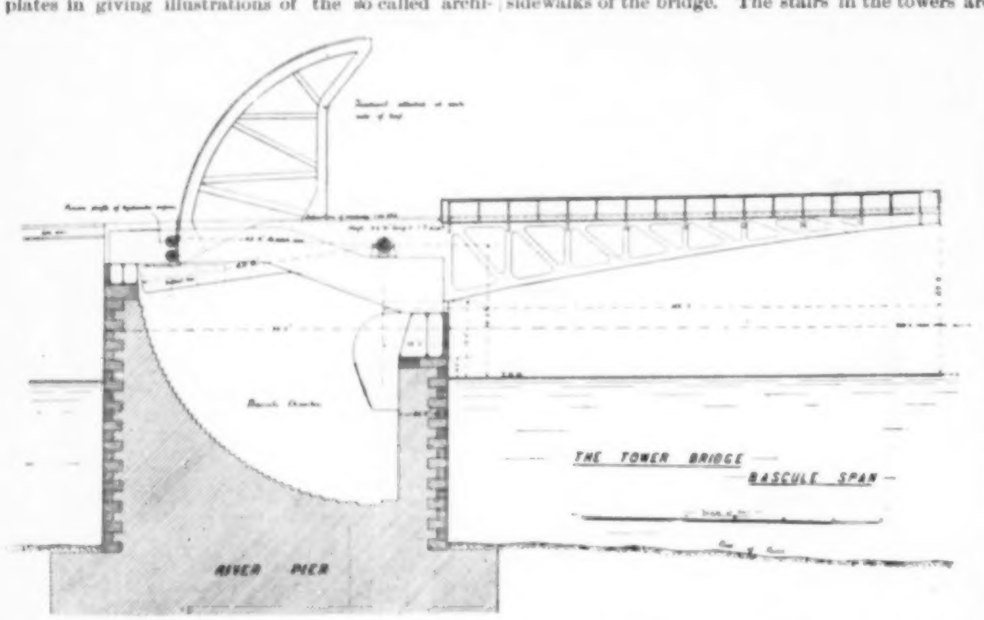
The Builder, London, from which we derive our sectional elevations, gives credit to the late Sir Horace Jones for the original design of the bridge, and says:

The design of the large towers was at all events much superior to their design as now carried out. The late Sir Horace Jones, though hardly what would now be called an 'art architect,' had a good deal more perception as to the artistic element in architectural design than would be quite realized by those who knew him only as the architect of the City markets. His design for the towers was a simple and somewhat impressive one, with a corbeled out upper story and angle turrets, somewhat after the manner of Scotch castellated Gothic, and a band of paneling a little way below them, the rest of the tower being very simply treated. It would have been better had it been still more simple, and had some of the windows and other ornamental features been omitted; but still it was in that form a fairly good design. Such merit as it had it has now entirely lost. The proportion of the whole has been entirely spoiled by bringing down the angle turrets a great deal lower, nearly half way down the tower in fact, thus completely destroying their expression as marking a massive crowning story. The method of corbeling them out also has been altered, and entirely weakened and spoiled, while instead of the architect's original single band of wall paneling, the tower is surrounded with a series of horizontal bands at equal distances. This is the engineer's improvement on the architect's design, we presume, the result of which has been to deprive it of any good qualities which it had in its original form. The sides of the towers are pierced with a number of windows that light nothing, with gewgaw "Gothic" decorations; some portion of these may have been the City architect's fault, though as far as we can make out there was hardly so much of this unmeaning window decoration on the original design. At all events, as they stand at present, the towers are about as choice specimens of architectural gimcrack on a large scale as one would wish to see.

This is the smallest part of the matter, however. Sir Horace Jones' original design was, it must be admitted, an acceptance of the absurdity that architectural structures in masonry were to be used to conceal the iron work, and to have the appearance of carrying immense suspension chains which they could not possibly carry. In this sense the design was vicious from the first. The stone gateway of approach to the bridge is a good design in itself, but it is entirely nullified and rendered absurd by the sight of the immense chains which are made to seem as if hanging over it and rove through openings in the masonry, though we know perfectly well that the masonry which is made to appear to carry them would be dragged to pieces even by such movements of the chain as might be caused by expansion and contraction of the metal. By a similar absurdity, the upper ends of the chains are made to appear as if supported by the large towers. It might be thought that architectural shamming could hardly go farther than this; but the engineer of the bridge has contrived to distance even this. Although the masonry towers are only envelopes, and could not possibly carry the chains which appear to be suspended across them, they have at least the aspect of being solidly built towers founded on the piers which carry the bridge. But even this is a delusion. Will it be credited that these masonry towers are actually built on and carried by the iron work; their side walls have no foundations at all, they are slung, as it were, in gigantic stirrups of steel, and at the period of our visit to the works you could actually look under the base of the walls into a vacant space above which they were hanging. What

will be the ultimate result on the masonry of thus depending on a large steel structure which must be subject to constant movement, future years will have to show. What strikes one at present is that the whole structure is the most monstrous and preposterous architectural sham that we have ever known of, and is in that sense a discredit to the generation which has erected it. Far better would it have been to have built simply the naked steel work, and let the construction show us what it really is; the effect, if somewhat bare looking, would have been at least honest, and we should have been relieved from the spectacle of many thousands spent on what is not the bridge at all—what is no part of its structure—but an elaborate and costly make-believe.

Under these circumstances we decline to waste any plates in giving illustrations of the so called architecture of the Tower Bridge, but we give measured drawings of the only part of the structure that is worth anything, viz., the constructive steel work (as it should be called rather than iron work), a side elevation of the whole structure, and a section of one leaf of the lifting or bascule bridge with the chamber in which the heel of it descends when the bridge is open.



THE TOWER BRIDGE, LONDON—ENLARGED SECTION OF BASCULE SPAN AND CHAMBER.

In regard to the general design, it should be mentioned that this is really a double cantilever, the suspension chains of each of the end portions being connected by the structure of the permanent high level bridge, which is in fact a tension bar uniting the chains.

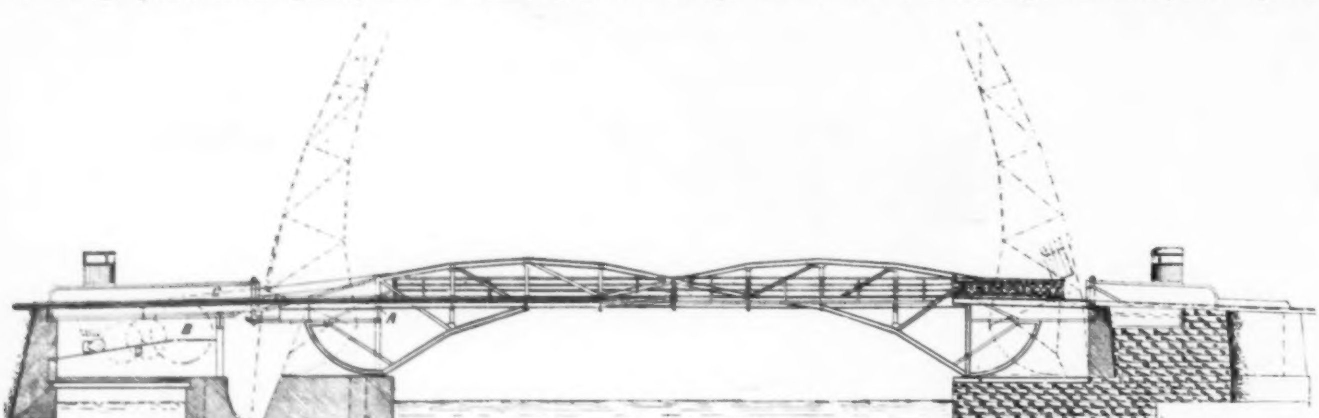
The two main piers had to be carried on at successive periods, as their simultaneous building would have rendered it impossible to keep the amount of waterway clear which was required from the contractors. The foundations formed in the caissons were of concrete of six of Thames ballast to one of Portland cement, shot in without any adherence to regular layers. The piers from the river bed upward are faced with rough picked Cornish granite, and the interior work built with wire-cut Gault brick, except where special strength was required, where Staffordshire brindle bricks were used; the whole in Portland cement mortar.

Sir William Arrol & Co. were the contractors for the erection of the steel work, which was supplied by the Steel Company of Scotland and some Glasgow firms. The construction of the main piers and of the bascule leaves will be sufficiently evident from the drawings. The bascule leaves are balanced on their centers, a great amount of lead having been used as dead weight in the short arms, and there is therefore practically no weight to lift in raising them—there is only the vis inertiæ and wind pressure to be overcome. The moving power is applied, as indicated in the section, by small toothed wheels working on the racks of the large quadrants. The power consists of hydraulic engines supplied with water from pumping engines and accumulators on the shore; and everything connected with this part of the work is in duplicate, so that there can be no danger of a breakdown from any temporary derangement of the machinery. The hydraulic engines are constructed by Sir W. G. Armstrong, Mitchell & Co.

The masonry contract, and also the roadway approaches, were carried out by Messrs. Perry & Co., the materials used in the construction of the towers being Cornish granite, Portland stone and brickwork. There have been a good many minor contracts in connection with the bridge. The ornamental cast iron work and decorative panels for the high level footways were made by Messrs. Fullaton, Hodgart & Barclay, of Paisley. Victoria stone has been used in the paving of the sidewalks of the bridge. The stairs in the towers are laid with Mason's "unwearable" non-slipping treads. The roadway over the moving portions was formed with a bed of creosoted Memel timber laid on the steel plates, 2 in. greenheart planks over this, and on this, wood paving blocks laid by the Acme Flooring Company on Mr. Duffy's improved system of banding together the blocks by keypieces and pins, inserted into cavities in the blocks, and holding the whole together as a compact mass. Messrs. Saxby & Farmer have carried out the signals for showing when the bridge is open. The Eddystone granite quarries supplied the granite which was worked to a great extent by Brunton & Trier's surfacing machines for the plain work, and their turning machines for circular and moulded work. The carving has been carried out by Messrs. Mabey & Son.

The bridge is lighted entirely by gas, and the lighting has been carried out by Messrs. W. Sugg & Co. with their high-power hexagonal gas lamps on the approaches, the opening span being lighted by four lamps of special construction, each of 400 candle power. The columns and brackets for the lamps have been cast to special designs made by Mr. G. D. Stevenson, A.R.I.B.A. Messrs. Sugg have also carried out the work of running the water mains and supplies, and fixing hydrants, tanks and handpumps in connection with them, during the progress of the works.

The engineer is Mr. J. Wolfe Barry, whom we may congratulate on the excellent carrying out of all the practical portion of what is essentially a great engineering work. So far it is a success; it is in attempting to make it an architectural work also that he has so lamentably failed.



VAN BUREN STREET, CHICAGO, DRAWBRIDGE.

VAN BUREN STREET, CHICAGO, DRAWBRIDGE.

The bridge to be built across the Chicago River at Van Buren Street is in its general design of the bascule type, a notable illustration of which is the Tower Bridge in London, which has just recently been completed and opened to the public. In this type of bridge the two sections forming the roadway are hinged or supported on trunnions on the abutments on either side, and raised and lowered at pleasure by power applied by different methods, according to the peculiar conditions of each case; but there are numerous objections to this style of bridge when applied to so limited a space as is admissible on the Chicago River. The Van Buren Street bridge, however, will embody the desirable features of the bascule with the objectionable ones eliminated. It was designed by William Scherzer, C.E., it being his last work before his death, and is being erected under the personal supervision of W. R. Roberts, C.E., the engineer in charge of bridges of Chicago.

On each side of the river, says the Western Electrician, to which we are indebted for our cut, is a substantial abutment, at the base of which, on the river side, is a pier on which lie two parallel horizontal steel rolling tracks provided with raised teeth and in line with the axis of the bridge. On these rolling tracks rest the segmental girders, having their center at A in the accompanying plan, and in the face of these girders are pockets corresponding with the teeth on the track. The weight of each section is so distributed that when it is raised to an angle of 45° the center of gravity passes through this center, so if there were no opposing strain a section would oscillate back and forth from its position. The left hand end is shown in section exposing the motors and the train of gears which transmits the motion for the bridge operation. On the deck of the bridge is shown the operator's stand. The operation of the bridge is as follows: To the center of the circle, A, is attached the operating strut, C, a rack suitably stiffened by channel beams which engages with the gear, B. The bridge in its closed position is shown by the full lines. The operator starts the motor which rotates the gear, B, thereby drawing back the strut, which, being attached to the center of the quadrant, causes it to roll back on the tracks, the teeth preventing it from slipping or skewing until it reaches the position indicated by the dotted line, when the motor is stopped automatically and a brake applied. In closing the operation is reversed, but before the ends are allowed to come together, by means of an automatic device the sections are brought to a full stop, thereby preventing the possibility of an accident through the carelessness of the operator. The final closing can then easily be controlled.

A powerful emergency brake is also provided, which may instantly be applied by the operator, thereby putting the entire operation under his complete control. The electric equipment will consist of four 50 horse power railway type motors, two on each section of the bridge, geared to a single horizontal shaft. Each pair will be controlled independently by a series parallel controller located in the operator's stand. The controlling mechanism, and particularly the braking devices, are exceedingly unique and interesting, and involve some novel features. The contract for this equipment has been awarded to G. P. Nichols & Bro., contracting engineers, Monadnock building, Chicago. Mr. Nichols is a pioneer in the application of electricity to the operation of large bridges, and has successfully equipped two at Lake and Rush Streets, and five in Milwaukee, the satisfactory operation of which has established Mr. Nichols' reputation in this line of work. The motors and controllers will be manufactured by the Westinghouse Electric and Manufacturing Company, and will be designed with reference to the unusual requirements of this class of work.

THE HALSTED STREET BRIDGE OVER THE CHICAGO RIVER.

In some respects, says Engineering, the problem to be solved was much the same as at the Tower Bridge, London. Some form of structure was required which, while giving when necessary a free way for high-masted ships, would obstruct the waterway and the river banks as little as possible. Hitherto the bascule type has been generally adopted under such conditions, and it was the favorite form of drawbridge during the middle ages, when such structures had a military rather than a commercial object. A moderate span was then all that was required, but when, at a more recent period, provision had to be made for the passage of large vessels, the swing bridge was invented, and up to the present it is still the favorite form where a large opening is required. In certain cases the swing has been as much as 450 feet long. A bascule bridge of similar span would be much more expensive, and, in fact, the Tower Bridge is, we believe, the only instance of a large bascule opening in existence. The increased expenditure in this latter case was considered justifiable on the ground that the bridges in a large

city should be as picturesque as possible, and it would have been disgraceful for a wealthy community like that of London to have permitted the erection of a structure that would not harmonize with the old Tower to which the new bridge is so close a neighbor. These latter considerations do not seem to have had much weight in the case of the Halsted Street bridge, which, though a capital piece of engineering and a great credit to its designer, Mr. J. A. L. Waddell, can hardly be considered a success from the æsthetic point of view, though this defect is not inherent in the type, and we have no doubt Mr. Waddell will be able to embody his idea in a more graceful form whenever he finds a community ready to pay for the luxury. Apart from this, the lift type seems to have great advantages, and there is no reason why the system could not be applied to an opening of as much as 500 feet to 600 feet if desired, and the cost in such a case would certainly be considerably less than that of a swing bridge giving an equal opening, and if the foundations were difficult, it might cost less than a swing bridge giving two 250 feet openings.

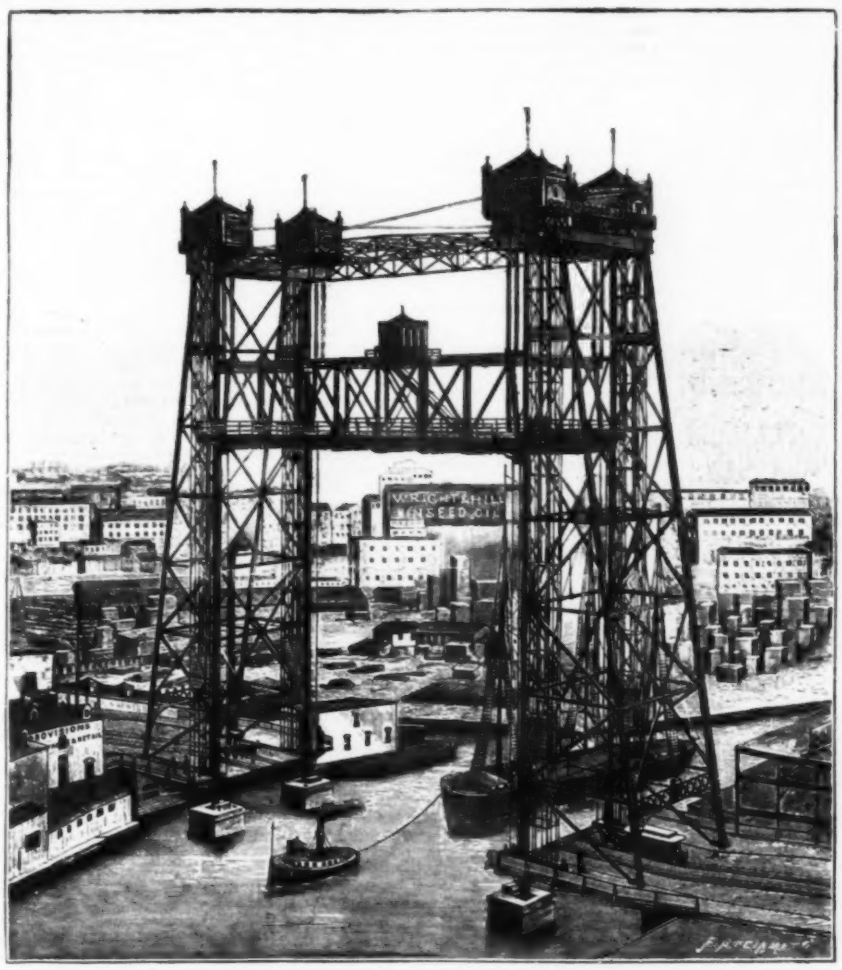
In general plan the type of bridge under consideration consists of an ordinary truss span, resting on masonry abutment as usual, but so arranged that the truss can be raised from its seat and lifted high above the water level, so as to permit of masted vessels passing beneath. The truss is of the ordinary pin-connected type, 130 feet long by 23 feet high, connections being formed for the roadway by prolonging the verticals below the bottom chord. This roadway is 34 feet wide between curbs, but the distance apart of the trusses, center to center, is 40 feet. The cross girders are of the plate type, and have the longitudinals, consisting of 15 inch I beams, riveted to their webs. The lower lateral bracing is fixed to the bottom flanges of these I beams. The pathways, 7 feet 8 inches wide, are carried on brackets, the pull of the top flange being carried round the vertical post. To guide the span while it is being lifted, two rollers are employed at each end of each top and bottom chord. One of the rollers is intended to take up side pressure, while the other checks any tendency to longitudinal swaying, but as provision must be made for expansion, this roller is fitted with powerful springs behind its bearings. The side pressure rollers are connected to the chords by a breaking piece, so that if the span is struck by a vessel the effect will be to shear this roller off, rather than to damage the span more seriously. A small hut for the bridge attendant is erected on the top of the lifting span.

The principal interest of the structure, however, centers on the lifting arrangements. As usual in the States, steam is employed for this purpose, an engine house being built on the river bank underneath one of the side spans of the bridge, and in this two 70 horse power engines have been erected, together with ample boiler power. These engines run at 240 revolutions per minute, and drive the pulleys for the lifting tackle by means of gearing. This tackle consists of 16 steel wire cables, $\frac{7}{8}$ inch diameter, eight of which attach to the top of the span and the other eight to the counterweights, the lead of the cables being so arranged that as one set is wound on the winding drums the other set is wound off. The main sheaves on the top of the towers are 12 feet in diameter, and as the span and its counterweights each weigh about 250 tons, these four pulleys have to carry about 75 tons each, and thus require a rather large shaft and long bearings. A 12 inch shaft has been adopted. To take the pull of the cables the two towers are connected together between the pulleys by a light truss. The abutment towers are very stiff, and consist each of two main vertical posts, which serve as guides for the lifting spans as well as taking most of the weight, while two raking posts support them against any end sway of the span when in its topmost position.

The bridge was designed by J. A. L. Waddell, C.E., of Kansas City, he having planned the same on a larger scale for Duluth Harbor. W. W. Curtis, engineer of the Pittsburg Bridge Company, made all of the working drawings of the structure, while the details of the lift gear were worked out by Superintendent T. W. Hermans, of the Crane Elevator Company.

The primary idea on which this type of bridge is based is the elimination of a center pier in cases where the bridge spans a navigable stream and a draw is necessary, thus securing the free use of the whole channel with very little obstruction of the docks in the immediate vicinity. This is accomplished by lifting the roadway to a sufficient height to allow passage of vessels with their spars and rigging, only for such time as is necessary, and immediately lowering to place, giving as little obstruction to street traffic as is possible. The bridge is so equipped as to be raised to full height in less than one minute, one engine being sufficient for the work, so that in this respect it is fully up to the ordinary center-pivot swing bridge, with the further advantage that in most cases it is only necessary to raise it part of the way, with the corresponding saving of time.

An accident which caused not a little excitement occurred recently in the working of this bridge. When the bridge was raised on the morning of July 16 to allow a vessel to pass under it, a pinion in the hoisting apparatus broke as the bridge reached its uppermost position, and it was impossible to lower the structure until repairs were made, which it took thirty-six hours to accomplish. At the time of the accident there were on the bridge eight passengers, of whom three, a policeman and two boys, were lowered in a chair tied to a rope, but five others, all men, were kept prisoners in their elevated position. A basket of provisions was sent up to them by a rope, and they passed the night as comfortably as they could in the signalman's little house.



THE NEW LIFT BRIDGE, HALSTED STREET, CHICAGO.

MINING AT THE ANTWERP EXPOSITION.

GOLD and silver mining are not without representation at the Exposition at Antwerp, which seems to be attracting hardly as much attention as it deserves. South Africa has taken a prominent part there in showing its resources. A stamp mill for crushing gold quartz is in operation, and is attracting a good deal of attention. It has been made at the Erith works of Messrs. Fraser & Chalmers, of Chicago, and it forms a part of the exhibit of the Transvaal Republic. The material treated is brought from different mines in the Transvaal; they have altogether 150 tons of quartz, and are working an hour per day. The chief novelty in this mill is in the method of feeding. A new arrangement of the "automatic challenge feeder" has been adopted, in which the whole of the feed apparatus is hung on iron bars running from the battery posts to the framework of the ore bin, instead of standing on a separate frame. In the "challenge" feeder the ore falls from the bin on a circular revolving table. An arm from the central stamp of the battery works a lever, which causes this table to turn, so that the delivery of ore is always proportioned to the speed of the battery, which is here set for 92 blows per minute. The ore is crushed wet in the usual manner, and then falls on to an amalgamated copper plate 12 ft. long by 5 ft. wide and set at an angle of 1½ in. to the foot. In the Transvaal the fall is usually rather less; but here it has been increased as an experiment. The mercury on the copper plate takes up the free gold in the mixture, and the remainder passes through troughs to two Frue vanners. The concentrates will be sent to England for treatment, probably also the slimes, if they are found to contain sufficient gold to make it worth while; but the free gold from the amalgamating table will be retorted at the exhibition.

In an adjoining building is the general exhibit of the Transvaal Republic. In the entrance hall are pyramids representing the annual gold export of the country. These are exhibited by the Chamber of Commerce of Johannesberg, and range from 230,189 oz. in 1888 to 1,478,114 oz. in 1893. There are also several other examples of the mineral production of the country, such as coal from different mines, a large block of silver-bearing galena, etc. In the hall on the left are chiefly agricultural products, such as grain and tobacco. There are also good samples of ostrich feathers and ivory, a little timber, and some native curiosities. On the right of the main entrance the exhibits are almost exclusively mineral.

The most interesting is probably a complete section of the Witwatersrand lode, near Johannesberg, with samples taken every few yards along the entire length of the lode. Specimens of various descriptions of gold-bearing quartz, of antimony ore and of various descriptions of galena are also shown; but these lose much of their value from the fact that no assay of any of the exhibits has been furnished, and that the explanation on the specimens has only been given in Dutch. A good many specimens of coal are also shown, mostly of poor quality, as is generally the case in the upper seams of a mine. Another very interesting exhibit in the same room is part of the core of a boring put down with a diamond drill at the Witwatersrand, to the depth of 2,442 ft.

The plans of the railway to Johannesberg are also shown. The line commences at Komati Poort, on the Komati River, where it joins the Pretoria and Delagoa Bay Railway, and goes to Leijdsdorp, on the Murchison Range, a distance of 225 miles.

Another interesting exhibit in the grounds is called "The American Gold Mine." It is a model, to the scale of ½ in. to the foot, of the first and bottom levels of the Saratoga Mines, in Colorado. Country rock and ore are in their proper positions, to scale; miners work in the shafts or in stoping, ore trucks run, buckets ascend, and the pump rods rise and fall—in short, the whole work of the mine may be seen at a glance. In the Saratoga mines the tunnels are run under the ore deposit, and the miners work upward, timbering where necessary. The scenery on the surface is a good representation of that part of the Rocky Mountain district, and pumping engines, winding engines and air compressors are all shown to scale. A train of mules conveys stores up a mountain path, and a stamp mill, like the one exhibited by the Transvaal, is working in one corner. A Halliday ropeway conveys the ore to the stamp mill, which is driven by a water wheel. Between the mines and surface there are figures of 80 men at work, and the model is altogether a complete piece of work.—The Engineering and Mining Journal.

ALLOYS.*

By J. T. HEWITT, D.Sc.

IN dealing with the subject of alloys, it will be as well to consider the subject from two points of view; (1) the methods by which they are produced; (2) their physical properties; and, if possible, to deduce from these heads some views as to their constitution.

Preparation.—Ordinarily, alloys are prepared by melting together the metals from which they are to be produced, and in many cases metals may be so alloyed in any chosen proportions. But another way of obtaining alloys was discovered by the Belgian chemist Spring (of Liege), who found that two metals might be alloyed if very strongly compressed. In 1878 and 1880 this chemist had found that various substances, when in a powdered condition, if subjected to a pressure of several thousand atmospheres, form blocks, which have the appearance of having resulted from molten material, and some substances which exist in different allotropic modifications pass by pressure from modifications of less to those of greater specific gravity. For instance, plastic and prismatic sulphur are both converted by pressure into the octahedral form, which has a higher specific gravity. Passing on now to mixtures of various substances, Spring found that combination might in some cases be effected by increase of pressure, viz., when the specific gravity of the resulting compound was greater than that of the original substance; and in this way an intimate mixture of copper and sulphur may be very readily converted by an increase of pressure into cuprous sulphide. Spring compared these facts with the liquefaction of gases by pressure, and also with the alteration of melting point by pressure, and put forward in consequence the following proposition: "That matter takes up a condition corresponding to the volume it is forced to occupy." Thinking that a good proof of this proposition might be given in the case of alloys, Spring examined the cases of some alloys which he was able to identify by their physical properties; if an alloy were formed the melting point would be lowered, while if no alloy had resulted, but only an intimate mixture of the metals employed, the melting point could not very well have changed.

Among Spring's experiments may be mentioned the formation of the alloys known so well as Wood's fusible metal, Rose's fusible metal and brass. For the first of these, cadmium, bismuth and tin filings were mixed in the necessary proportion and subjected to a pressure of 7,500 atmospheres; the resulting block was then once more reduced by filing to a fine state of subdivi-

* A paper read before the People's Palace Chemical Society, London.

sion, and again made into the block condition by compression. The substance obtained in this way corresponded in density, color, hardness, brittleness and fracture to Wood's metal, and melted in water heated to 70°; Wood's metal fuses at 65°.

For the experiments with Rose's metal, Pb, Bi and Sn were mixed in the right proportion, and after two pressings a block was obtained which melted in boiling water; Rose's metal melts at 95°.

In attempting to alloy copper and zinc, Spring found it was necessary to reduce the product to powder five or six times, and then to repeat the pressure, but by this process a block of brass was obtained, agreeing in properties with that obtained by fusion, except that the color was slightly darker. The repetition of the filing and pressing is not hard to explain in this case, as brass has a density differing but little from that of the metals it is produced from, hence the first effect of compression is merely to produce a conglomerate of the two metals, instead of an alloy in which the existence of the two metals cannot be detected by sight.

It is interesting to note in this connection that an inverse change has also been effected in some cases; thus Spring and Van 't Hoff have found that the double calcium copper acetate $CaCu(C_2H_3O_2)_4, 8H_2O$ may be decomposed by long-continued pressure into its constituents. Here we have the double salt with a less specific gravity than its constituents, and it obeys Spring's law and takes up the form it is compelled to.

Another way by which alloys may be produced is by heating the intimately mixed components to a temperature higher than the melting point of the alloy, but not so high as the melting points of the individual metals from which the alloy is to be produced; such a method was observed by Hullock, who did not employ increased pressure (Zeit. f. phys. Chem., II., 378).

Physical Properties.—From the year 1860 onward, a series of important researches on the electrical conductivity of alloys was published by Dr. Matthiessen, and he came to the conclusion that the conductivity curves assume three distinctive forms, either a U, as with gold-silver alloys, L shaped, as in the copper-tin series, or nearly a straight line with alloys of lead and tin. Matthiessen also came to the conclusion that in certain alloys the metals that enter into their composition assume allotropic forms.

The passage of a current of electricity through various molten alloys has been experimented upon. Gerardin has stated that electrolytic decomposition takes place, but this has been denied by Obach, and Roberts-Austen was unable to decompose alloys of lead with gold or silver by a current of 300 amperes; he considers that there may possibly be a group of bodies between true alloys and true electrolytes, in which a gradual change from metallic to electrolytic conduction occurs. This would be analogous to the case of the sulphides of silver and copper, which conduct in the metallic manner at ordinary temperatures, but undergo electrolysis when the temperature is increased.

We now pass on to a consideration of the ways in which alloys may be regarded. An alloy may be looked upon very much as a solution which has solidified, and in the case of solutions we have two great theories in vogue, one rather more so than the other. The first of these theories, which is known as the "hydrate theory," supposes that when a solid substance is dissolved in a liquid a number of liquid compounds of solvents and dissolved substances are formed; and it would therefore be of advantage to isolate the compounds if possible. Such work has been attempted and described by Pickering in the case of aqueous solutions, and a good many attempts have been made in the case of alloys to obtain compounds of definite composition. Coming to the method of liquation by which metals may sometimes be separated from one another, we have the cases given of the alloys Cu_3Sn, Cu_4Sn, and $Cu_{12}Sn_2$, which refuse to liquate on heating. If we took alloys of copper and tin of varying composition, we should expect then to find some break in the physical properties at those points where the compositions denoted by these formulæ were reached. Such have been observed, Lodge finding electrical conductivity a minimum at Cu_4Sn, and a maximum at Cu_3Sn. Calvert and Johnson getting similar phenomena for the heat conductivity. Mr. Laurie also worked out a very ingenious method, depending on the extent one metal was polarized when another metal was alloyed with it.

From the evidence just quoted it would seem as if definite compounds of metals could be obtained, and an alloy would then probably be an intimate mixture of such a compound with an excess of one or other metal.

But there is another way in which we may look on alloys, that is from the standpoint of the physical theory of solution.

The application of the physical theory of solution to the case of alloys has been attacked by the two Cambridge chemists, Heycock and Neville, who during the past few years have published a succession of papers in this direction. If when a small quantity of one metal is dissolved in another in a state of fusion, the phenomena are analogous to those of the solution of a substance in a solvent, we should expect the dissolved metal to lower the melting point of the solvent metal in the same way that the freezing point of any other solvent is lowered. This we know to be true qualitatively, alloys usually melting at a lower temperature than their constituents. It now remained to make quantitative determinations, and to see if Raoult's laws as to the freezing points of solvents applied to the case of metals.

Raoult's laws are:

1. The fall of freezing point of a solvent varies as the weight of substance dissolved.
2. Molecular weights of different substances produce the same fall whatever the substance may be.
3. If a constant number of molecular weights of the solvent be taken, the fall produced is independent of the nature of the solvent.

Heycock and Neville worked with the alloys in blocks of iron, stirring them while melted; with thermometers they could read to $\frac{1}{10}$ of a degree; at the moment of solidification the highest temperature observed was recorded and taken as the melting point of the alloy. In this way Raoult's first law was found to apply, the second also was probably true, and if one assumed that mercury dissolved in another metal consisted of molecules containing only one atom, as is true for mercury in the gaseous state, it followed that the other metals in solution also possessed molecules consisting of only one atom in most cases.

Raoult's third law proved, however, to be probably incorrect. Many metals were used both for solvent and dissolved substance; in the case of gold dissolved in sodium, it was found that the sodium was saturated when 15 per cent. of gold had been added. In certain cases effects were observed very similar to those obtaining in ordinary well-known cases of solution. Silver proving to be insoluble in sodium, an attempt was made to bring it into solution by first amalgamating it with mercury and then adding this amalgam to the sodium; but the lowering of freezing point observed was entirely accounted for by the mercury that had been added, the silver having been probably thrown out of solution in an exactly similar way to the manner in which resin is precipitated when water is added to its alcoholic solution. As the alcohol mixes with the water while the resin separates, so had the mercury alloyed with the sodium while the silver was not dissolved.

Experiments were also made to see the effect of adding two metals to an excess of a third solvent metal, and here the effects were found to be independent of one another. Gold was first added to tin, and the freezing point curve plotted; then on adding cadmium, a further regular fall was produced, the effect being independent of that of the gold. After a certain addition, irregularities, however, were found in the curve such as are represented in the diagram.

Increasing concentration should produce increased osmotic pressure, and hence deviations resembling those observed by Anagot in the case of gases should be found, i. e., the atomic fall should not be so great at a greater as at a less concentration. Polymerization at increased pressures (concentrations) might be expected, as in the cases of acetic acid, iodine, and hydrogen fluoride, but no evidence of this has been obtained. There is yet another way in which atomic falls less than the theoretical might be brought about, that is, that a portion of the solvent metal at the moment of freezing might carry down some of the dissolved metal with it. This would decrease the osmotic pressure, and as the work done before solidification would not be so great, a smaller reduction of temperature would take place before freezing set in. This cause might in extreme cases even bring about a raising of the freezing point, and such has in fact been observed in the cases of antimony in tin, antimony in bismuth, and silver in cadmium. While the precipitate which separates is poorer in dissolved metal than the liquid, there must be a compression of our hypothetical gas and a lowering of freezing point; if on the other hand the precipitate contains more of the foreign metal than the liquid portion, then the sign of the work done is changed, and the freezing point is raised. In these cases the precipitate probably consists of a definite chemical compound of the two metals.

That definite compounds are obtained in certain cases was proved by Heycock and Neville, by dissolving gold in a large excess of cadmium, and then distilling off the excess of cadmium in a vacuum. The alloy thus left gave analytical numbers corresponding to the empirical formula Au Cd.

	Calc.	Found.
Au	63·71	63·98

The alloy somewhat resembles cadmium in appearance, is scarcely attacked by cold nitric acid, but has the cadmium removed by hot hydrochloric or nitric acid.

This is very interesting as showing us how silver and cadmium probably also unite together, with the result that silver dissolved in cadmium raises the freezing point of the latter, the separated substance being richer in silver than the remaining liquid.

The conclusions which I think we may be justified in drawing from Heycock and Neville's work are:

1. That in certain cases compounds of two metals may be obtained.
2. That in the majority of cases the alloying of one metal with another merely means that we obtain a solution of one metal in another in the same way that sugar may be dissolved in water; we lower the freezing point of the solvent metal just as we lower the freezing point of the solvent water.

GASEOUS AND LIQUID AIR.*

In the last three of the course of six lectures by Professor Dewar at the Royal Institution, on "Gaseous and Liquid Air," in dealing with the power of the sun, he said that the total heat of the sun is capable of evaporating a layer of water over the entire surface of the earth equal to 9 ft. The average rainfall over the entire surface of the earth is 4½ ft.; thus the difference between the two represents the heat conveyed to the soil and atmosphere, which is equivalent to the amount required to evaporate 4½ ft. of water. Much of this heat is utilized in the formation and decomposition of cellulose. The following equation represents the ultimate effect of the action of sunlight on the leaves of plants, and how it separates oxygen from carbonic acid:

$$\underset{\text{Carbonic acid.}}{6\,CO_2} + \underset{\text{Water.}}{5\,H_2O} = \underset{\text{Starch cellulose.}}{C_6H_{10}O_5} + \underset{\text{Oxygen.}}{O_{12}}.$$

One square meter of leaf surface produces 1·65 grammes of starch per hour, and absorbs in the process 4·68 units of heat. The total energy received in the same time from solar radiation on the same area amounts to 622 units. The ratio of potential to available energy is 1 to 132, but if the luminous portion of the spectrum alone be considered, the ratio is 1 to 33:

$$\underset{\text{Cellulose.}}{C_6H_{10}O_5} + \underset{\text{Water.}}{H_2O} = \underset{\text{Marsh gas.}}{3\,CH_4} + \underset{\text{Carbonic acid.}}{3\,CO_2}.$$

When speaking of the absorption of the oxygen of the air by different media, Professor Dewar pointed out that oxygen dissolves in India rubber more readily than does nitrogen, so that if one side of a thin sheet of India rubber be exposed to the air, and suction applied to the other side, the air passed through the India rubber is much richer in oxygen than before; indeed, sufficiently rich to reinflame a smouldering wooden splint. One method by which he did this was to fill a little India rubber balloon with sawdust to keep its sides extended, and then to slowly draw air through the thin rubber. Silver has the property of absorbing oxygen at a high temperature, and of giving it out at a lower one; he took some molten silver at a white heat, and, as it somewhat cooled, the oxygen began to come off from little silver craters formed by its own bubbles. The lecturer showed that the gas coming from these little volcanoes would reinflame a glowing splint. The vigorous way in which ozone will attack certain organic substances was illustrated by an experiment showing its action on good tough samples of India rubber, which it rendered rotten in an instant.

The lecturer gave the following table to show the large part oxygen occupies in the terrestrial economy:

Composition of the Earth's Solid Crust in 100 Parts by Weight.

Oxygen	44·0 to 48·7
Silicon	22·8 to 36·2
Aluminum	9·9 to 6·1
Iron	9·9 to 2·4
Calcium	6·6 to 0·9
Magnesium	2·7 to 0·1
Sodium	2·4 to 2·5
Potassium	1·7 to 3·1

He said that nearly half the weight of the solid crust of the earth is due to oxygen, and that eight-ninths of the waters of the oceans consist thereof. This oxygen, he added, is a body of a pale blue color, and to show that it has color, he took a strong metallic tube about 6 ft. long, plugged at each end apparently with thick glass, but perhaps rock crystal, and condensed oxygen within it to a pressure of 100 atmospheres. White light from the electric arc was then passed through the gas from one end of the tube, and its spectrum was cast upon a small screen near the other end. This spectrum exhibited well marked dark absorption bands in the blue, orange, and yellow-green. He then slowly allowed the gas to escape, and the bands gradually grew fainter, until at a pressure of 50 atmospheres they were almost invisible; at a slightly lower pressure they disappeared altogether.

The lecturer stated that in freezing water by the evaporation of ether, a large amount of ether has to be volatilized, and that all the processes for the production of intense cold are anything but economical; therefore the expensive substances used are mostly evaporated in closed vessels, so that they can be liquefied once more, and used over and over again. Carbonic acid snow has a boiling point lower than its melting point, which is the converse of that which commonly occurs; this boiling point is 80° C. below the melting point of ice, or colder than any temperature which has been met in the Arctic regions, the greatest cold yet found there being about —60° C., in extreme cases. Carbonic acid snow, in air, is a boiling solid, and it can be made to boil quicker by diminishing the pressure on its surface, but for some experimental purposes a liquid is most convenient to employ in the production of low temperatures; one of these consists of nitrous oxide or laughing gas compressed and chilled into a liquid, which liquid boils at a lower temperature than carbonic acid snow, namely, at —90° C.; both these substances can be made to give greater cold still by evaporating them in a vacuum; in this way carbonic acid will give a temperature of —110° C. Their method of getting extremely low temperatures was to reach them step by step, by means of cold and pressure used to liquefy one gas after another, employing each in its turn to obtain a lower temperature still. By evaporation of liquid nitrous oxide they produced liquid ethylene, the boiling point of which is —100° C., or 100° below the melting point of ice; it does not solidify, and it does not freeze, so is very convenient for his purposes. The evaporation of ethylene in vacuo gives a temperature of —140° C. The liquid is exceedingly volatile, a kind of petroleum, and no light must be brought near it; when thrown upon cold water it hisses because the water is so hot to it; sometimes there is almost an explosion when they come into contact. They would notice that the drops of ethylene on the water formed for themselves little cups of ice in which they floated about; he would light the ethylene in the cups, so that they could see little islands of flame curving about on the water.

When by means of liquid ethylene evaporating in a vacuum a temperature of —140° C. is reached, and oxygen is compressed at that temperature, the latter gas becomes liquid. He could not take them into the laboratory to show how it was done, but he had a bottle of liquid oxygen on the table before him which had been made four hours previously, and he would project on the screen a few lantern slides showing the machinery employed in compression. The liquid in the flask before him was boiling very slowly; the flask was a double one with a vacuum between its two skins, which prevented to a great extent the entrance of heat from without; he could hold it in his hands, as they saw, without feeling any cold whatever, and the outside of the vessel was not bedewed with moisture. They would notice that the liquid had a pale blue color, and was opalescent, because of fine particles in it, probably of carbonic acid, which he would separate by filtration. The boiling point of oxygen is —180° C. On his pouring some of the liquid oxygen on ice, they would notice that it rolled about like a liquid on a very hot plate; in fact, the ice was relatively so hot to the liquid oxygen that the latter assumed the spheroidal state.

Professor Dewar then gave the following figures:

Pressure of Liquid Oxygen.

Temperature. Deg. C.	Pressures in Atmospheres.
—129·6	27·02
—131·6	25·85
—133·4	24·40
—134·8	23·18
—135·8	22·20

The critical point of oxygen is —133° C. at fifty atmospheres critical pressure; its boiling point about —180° C.; the density of the liquid = 0·89 at —130° C.

The pressure of the vapor of liquid oxygen increases 1⅓ atmospheres per degree. The density of liquid oxygen at —140° is about 0·88. The coefficient of expansion is 0·017, or four and a half times that of a gas, or two and a half times that of liquid carbonic acid. The gas at 17° compressed to 4,000 atmospheres reaches a den-

* Report of *The Engineer*.

sity of 1·25. The limiting density of hydrogen is 0·12. "The lowest temperature yet reached is —210° ?"

The lecturer stated that some inquisitive young person had asked him the cost of liquid air, but as the treasurer to the Royal Institution as well as some other officers were present, he thought it wisest to give no answer, otherwise they might put a stop to the researches and experiments. The cost had been paid by a few private individuals and by a liberal donation from the Goldsmiths' Company. The cost was reduced as much as possible by working the refrigerating liquids and gases round and round in closed circuits, so that they could be used over and over again, for they were expensive.

In a double flask on the table before him he had about half a pint of liquid air; he said that it could be handled well, because if any drops fell on the hands they assumed the spheroidal state, and did not hurt. To show how slowly it was evaporating, he collected some of the gas given off in an inverted tube dipping into the pneumatic trough, so that the slow rate could be seen. He said that such a supply as he had on the table could be kept for thirty or forty hours. He then performed a few experiments already described in these pages, including showing that vapor of mercury is present in the Torricellian vacuum by freezing it into a mirror on the interior of the glass. He also froze alcohol into little lumps, and showed that when they first liquefy they have the viscous consistency of glycerine; the alcohol froze at 120° C. below zero by dropping it in liquid oxygen. The lumps of alcohol were so cold that they would not burn when a flame was applied to them; sodium and phosphorus likewise could not be inflamed at the temperature of liquid oxygen. He produced a snow storm of carbonic acid by allowing some of that gas to enter a glass vessel in which liquid oxygen was evaporating.

Sodium floated on liquid oxygen without combining therewith. By means of an induction coil Professor Dewar showed that liquid oxygen considerably resists the passage of an electrical discharge; the same amount of energy required to produce a spark in liquid oxygen will give one six times as long in air. He then showed, by experiments already described in these pages, that liquid oxygen is magnetic, as Faraday had proved gaseous oxygen to be in that theater fifty years ago. At —180° C. oxygen is three times denser than air, and twice as dense as carbonic acid. He here repeated the pretty experiment, already published, of evaporating liquid oxygen in a vacuum, which made the containing test tube so cold that the air of the theater condensed to a liquid upon its outside, and fell from the bottom of the tube in drops at the rate of two a second. The temperature inside the tube was 205° C. below zero. He measured these low temperatures in public with the utmost precision and exactitude, by means of a thermal couple placed in the evaporating liquids; the indications were given by a reflecting galvanometer; the scale was many yards long, occupying nearly the whole width of the theater.

When evaporating liquid oxygen in a vacuum for about ten minutes the liquid gets the better of the air pump; then everything gets cold, and air can be liquefied at the normal pressure with fair rapidity. The oxygen gas given off at this low temperature is so cold that it will not reinflame a smouldering wooden splint. When common air is liquefied, the nitrogen boils off before the oxygen. Professor Dewar pointed out that the liquid air in the bottle before him was of a lighter blue color than liquid oxygen, and not so opalescent; its spectrum, he said, was the same as that of oxygen, not so strongly marked, but the bands grew darker as the nitrogen boiled off. The thermometer in melting ice as he showed by his thermo-electrometer, gives the zero of the Centigrade scale, and when the metallic couple is next placed in liquid air, gives —190° C., which is its true boiling point.

He concluded by saying that there had been liberality in the expression of opinion as to what lectures are and what lectures are not suitable for the young, but the Christmas lectures at the Royal Institution are not professedly educational; they are stimulating. In after years the young people among those present would feel the advantages of so much as they had learned from the Christmas Royal Institution lectures. He was much indebted to his two assistants, Mr. Lennox and Mr. Heath, for the way in which they had executed the large amount of work in preparing for these lectures.

Although Professor Dewar has not given the full details of his method of liquefying oxygen and air in bulk, he has published the scientific principles employed, in a variety of different directions. For instance, he stated to a correspondent of *McClure's Magazine*:

"The process of liquefying oxygen, briefly speaking, is this: Into the outer chamber of that double compressor I introduce, through a pipe, liquid nitrous oxide gas, under a pressure of about 1,400 lb. to the square inch. I then allow it to evaporate rapidly, and thus obtain a temperature around the inner chamber of —90° C. (—130° F.) Into this cooled inner chamber I introduce liquid ethylene, which is a gas at ordinary temperatures, under a pressure of 1,800 lb. to the square inch. When the inner chamber is full of ethylene, its rapid evaporation under exhaustion reduces the temperature to —145° C. (—229° F.) Running through this inner chamber is a tube containing oxygen gas under a pressure of 750 lb. to the square inch. The 'critical point' of oxygen gas, that is, the point above which no amount of pressure will reduce it to a liquid, is —115° C., but this pressure at the temperature of —145° C. is amply sufficient to cause it to liquefy rapidly. In drawing off the liquid under this pressure, I lose nine-tenths of it by evaporation."

The same journal says that by evaporating oxygen he is able to solidify air under pressure at —207° C., also nitrogen, which becomes a white crystalline substance at —210° C.

ORTHOCHROMATIC PHOTOGRAPHY.

Mr. W. A. Cooper, in Humanity and Health, tells about orthochromatic plates as follows: For years after the dry plates were introduced, I continued the use of the old wet process in my photo-mechanical printing business, because we required negatives of greater strength and crispness than could be obtained with the dry plates.

The originals we copied from then were chiefly engravings, etchings, photographs and foreign prints of all kinds that were not copyrighted. We soon began reproducing paintings by our young and promising artists, and found the old wet process that gave such good negatives from black and white originals fell far short when it came to copying paintings in color. The blues, violets, purples and all the lighter shades photographed perfectly white, while the yellows, reds, the oranges and greens photographed almost black. We began then to use the ordinary dry plates and found them very much better, being so very rapid gave greater details and consequently better values, but still we did not get the results we wanted, the proper color values.

Before orthochromatic plates were put on the market, we experimented by soaking our ordinary dry plates in dyes that made the plates more sensitive to the yellows and reds of the painting. This worked satisfactorily.

It was not long before the makers of dry plates began the manufacture of the orthochromatic plates and placing them on the market. These we have used ever since with a great deal of pleasure and satisfaction; they are a deal better than those you prepare yourself, because the dyes, being mixed with the emulsion before coating the plates, do not deteriorate as quickly. In fact, I find very little, if any, difference between the keeping qualities of the orthochromatic plates as now made and the ordinary dry plates.

It is a mistaken idea that these plates are only of special value in copying paintings, flowers, etc. They are of inestimable value to the studio, not in special cases of blue eyes and red hair with an abundance of freckles (in this case, possibly, they show more pronouncedly their great value, being the strongest test they can be put to), but in all kinds of studio work. In the case just mentioned, of the blue eyes, etc., I would recommend the use of a light lemon-colored screen back of the lens. It increases the exposure from three to five times, but with such rapid plates this is of very little importance compared with the result obtained.

Their value in landscape work can scarcely be estimated, now it is possible to catch a passing cloud without sacrificing the foliage.

There are special cases in outdoor work where the use of a screen back of lens or in the diaphragm is advised where there is great contrast of light and shade; a dark foreground with a strongly lighted distance, banks of white clouds against a deep blue sky. For subjects like these a light, delicate yellow screen may be used with great advantage with very little increase in exposure.

I wish particularly now to speak of a new plate I have recently been using on interior work. They are the Wuestner H. non halation orthochromatic plate. It is possible with these to photograph against the light of windows without a particle of halation or solarization. They are made on scientific principles, and Mr. Wuestner is to be congratulated, for this is a great improvement over the old method of overcoming the difficulty of halation.

I will explain the way these plates are made, that my readers who wish to work them may do so intelligently. They are triple coated with a varying sensitiveness, and all three coatings possessing the orthochromatic qualities. The first coating is a very slow emulsion, the second a little faster and the third the most rapid emulsion he makes, all perfectly united, with no fear of separation or frilling.

I have recently used these plates on many interiors in some of the handsomest houses in New York. They were so satisfactory when I photographed against the light that I used them all through the house, even where I photographed with the light. These negatives have been highly complimented; they possess wonderful detail. I timed them all for the deepest shadows, but none of them were overtimed. All the delicate half tones of the lace curtain are preserved, and not a particle of halation.

In developing these plates less pyro may be used, and don't look for the image to show through the back, as in thinly coated plates; they also take much longer to fix.

There is no reason why the orthochromatic plate will not entirely supplant the ordinary everyday plate. There is no class of work in the whole range of photography, professional, amateur, scientific and surgical, that it will not do better. They are so easily handled and worked, the only extra care necessary is the quality of light used in dark rooms. Cover the ordinary ruby light or lamp with one thickness of post office paper; this will make your light perfectly safe.

Any developer may be used with these plates. I personally use and prefer the pyro. It gives a printing color and quality to the negatives I cannot secure with any other developer.

I paid a visit to the factory of Mr. E. Wuestner, 26 Jackson Place, Jersey City, where these truly wonderful plates are made, and through the kindness and courtesy and under the personal supervision of Mr. Wuestner, witnessed the entire operation.

We were first conducted to the room where the glass is cleaned and receives its first coating of gelatine and chrome alum; this is done by an ingenious little machine; the plates are then dried spontaneously and stored away ready for the sensitive coating.

We pass into the coating room through a series of winding passages, Indian file, holding each other's hand, for here all white light is excluded and everything as black as midnight, excepting a ruby-red light here and there through the vast place. We soon became accustomed and found ourselves surrounded by machinery and men and women busy as bees. The glass plates that we saw preparing out in the light are here passed into a machine three or four abreast and receive the coating of sensitive emulsion, which is white, like cream, and of that consistency. This is poured into a V-shaped trough, and as the plates pass under, receive the coating evenly and are carried along over a series of ice-cold rollers the length of the room. By this time the emulsion, which the plates receive warm, is in the space of a few seconds chilled and set. They are lifted from the rollers and examined. Poorly coated or defective ones are thrown aside; the goods are stood in racks to dry overnight. Next day they are placed in a room to kiln dry and remove all humidity. Before being cut up into regular sizes they are examined by an expert close to a ruby light, and any imperfection is quickly detected and thrown aside. After cutting into sizes they are packed in boxes by young girls and are sent to the shipping room. All this is done, of course, in these red-lighted rooms, but the help soon get accustomed and seem to enjoy their work, and the hours are very short. Cleanliness and absence of white light are the two essentials here; the machine does the rest.

But it is in the preparation of the emulsion that science and chemical knowledge is necessary. This is carefully looked after by Mr. Wuestner or one of his boys. After making, it is stored in large earthen jars, for use in the factory or shipped to Canada, where the celebrated Eagle plates are made for our northern neighbors.

The plant is a large one, covering about half a block, and was specially built by Mr. Wuestner for making these plates. We asked him the capital invested; he pointed to his two stalwart sons and said, "There is my capital."

[From Astronomy and Astro-Physics.]

PHOTOGRAPHIC DETERMINATION OF STELLAR MOTIONS.*

By Edward C. Pickering.

A great advantage of photography as a means of studying astronomical phenomena is the ease with which a vast number of facts may be collected. These facts are recorded in permanent form and later may be deduced or verified. An attempt has accordingly been made at the Harvard College Observatory to detect by photography stars undergoing considerable change in position, either owing to parallax or proper motion. Two methods have been employed for many years in comparing photographs of the same parts of the sky. First, by superposing two negatives of the same region, in which case the images of the stars will form curious sets of concentric circles, if the plates are not exactly oriented. Since the two films are separated by the thickness of one plate of glass, small differences in position cannot readily be detected in this way. Secondly, if a contact print is made from one negative and the other negative is superposed on the positive thus formed, the dark images of one plate should fill the light spaces in the other, and give a nearly uniform surface. In actual practice this method was found here less satisfactory than might be anticipated, although highly recommended by Professor Barnard (Astron. Nach., cxxx., 77). A cluster appears to be the best object for this method. If the plates are not exactly superposed, each star appears to project slightly from the background and to cast a shadow on one side.

A third method has accordingly been tried. A photographic plate is placed in the plate holder with the film side away from the objective, the photograph being taken through the glass. The character of the images thus obtained does not seem to be affected. Theoretically, the plate holder should be moved toward the objective by two-thirds the thickness of the plate, but the correction is scarcely perceptible with a large telescope. When such a photograph is superposed upon a photograph taken in the usual way, the two films being placed together, all the images of one should appear to coincide with those of the other, the difference in the planes of the two images not being noticeable even when viewed under a considerable magnifying power.

This last method has been in use for the past three years at the Harvard College Observatory with the 11 inch Draper telescope at Cambridge and with the 13 inch Boyden telescope at Arequipa. A number of objects, about a hundred and fifty in all, have been selected, including variable stars of long period, of short period, Algol stars, stars whose spectrum is of the third, fourth or fifth type, binary stars, stars having large proper motion, etc. The two dates are computed on which the longitude of the sun should differ 90° from the longitude of each of these objects. Within a few days of each of these dates, two photographs are taken, one with the plate in the usual position, the other with its film reversed. Generally, an exposure of about ten minutes was given to each. The first of these plates was taken in August, 1891.

The examination is made by superposing one plate upon another taken six months later and in the opposite position. Thus a plate taken in January with the film turned toward the objective is placed upon the plate taken in July with the film turned from the objective. The other two plates are also superposed. Instead of making the images exactly coincide, one plate is moved so that all of its images shall be exactly north of those on the other plate by a very small amount, for example, 10″. The plates then appear to be covered with double stars having the same position angles and distances, with components nearly equal in brightness. If now the two images of any star differ in brightness it may be variable, and if the position angle is different from that of the adjacent stars, it may be suspected of proper motion, or of sensible parallax. In any case, confirmation may be obtained at once from the other pair of plates. A third pair of plates should always be taken one or more years after one of the first dates, and thus serve to distinguish between parallax and proper motion. In the actual examination a microscope is used having a field rather more than a centimeter in diameter and traversed by a vertical cross wire. Sweeps are made moving the plate in right ascension, and after each sweep changing the declination by moving the plate one centimeter at a time, until the whole plate has been examined. As each star in turn is brought past the cross wire the direction of the line connecting its components is determined with much accuracy. The diameter of the images should not exceed two to four seconds of arc, and they may be placed about ten seconds apart. A parallax of half a second will then change the position angle by about five degrees, a very noticeable quantity. The conditions under which the plates are taken give nearly the maximum value of the displacement in right ascension due to parallax. This corresponds to a change in position angle to which the eye is much more sensitive than to changes in distance. Any suspected objects are marked upon the photographs and confirmed or not on the other plates. If the

* Communicated by the author.

change in position is real, the same method may be used with great advantage for determining its amount. In the usual method, it is necessary to measure the position of each star from several adjacent companions, which involves measurements of several hundred seconds and the application of various corrections for difference of scale, orientation, differential refraction, etc. The results are then brought together and the outstanding differences are discussed. In the present case the work is purely differential. We have only to measure the position angles and distances of what appear to be double stars whose components are nearly equal and to which any convenient position angle and distance may be given. Personal equation dependent on position angle is evidently eliminated. Such effects as differences in scale of the two plates, error in orientation and differential refraction then appear only as linear terms whose values are readily determined. Incidentally an inspection of these plates shows that no slipping of the film is sensible, but such a source of error, if it occurred, would affect all determinations of position from photographs. Although considerable progress has been made in taking the photographs, much time has not yet been spent in studying them. An examination has been by Miss L. D. Wells of 1436 stars on eight pairs of plates, and shows that probably none of these stars have a parallax of as much as half a second. Ordinarily, a pair of plates can be examined in about half an hour.

A preliminary measure of the positions of the images of eight stars in the vicinity of the variable star T Cassiopeiæ gave the average deviation of the uncorrected differences 0·23″, which would correspond to a probable error in the parallax of but little over a tenth of a second as derived from measures of a single pair of plates.

Evidently in a few years the value of these plates will be greatly increased as a means of measuring proper motions. In ten years the work should be repeated and a proper motion of one tenth of a second would then give a displacement of a second, which, as shown above, would be readily detected by inspection and could be measured with accuracy.

The question has presented itself how far it may be best to photograph the entire sky with the Bruce telescope with plates in both positions, for determining the proper motion of large numbers of stars. The advantages of this method increase in many respects with the focal length of the telescope. The ease with which photographs suitable for this work may be taken with any photographic telescope is the reason for the present publication of a description of this method.

Harvard College Observatory, Cambridge, U. S. July 8, 1894.

[From a Correspondent of the Scientific American.]

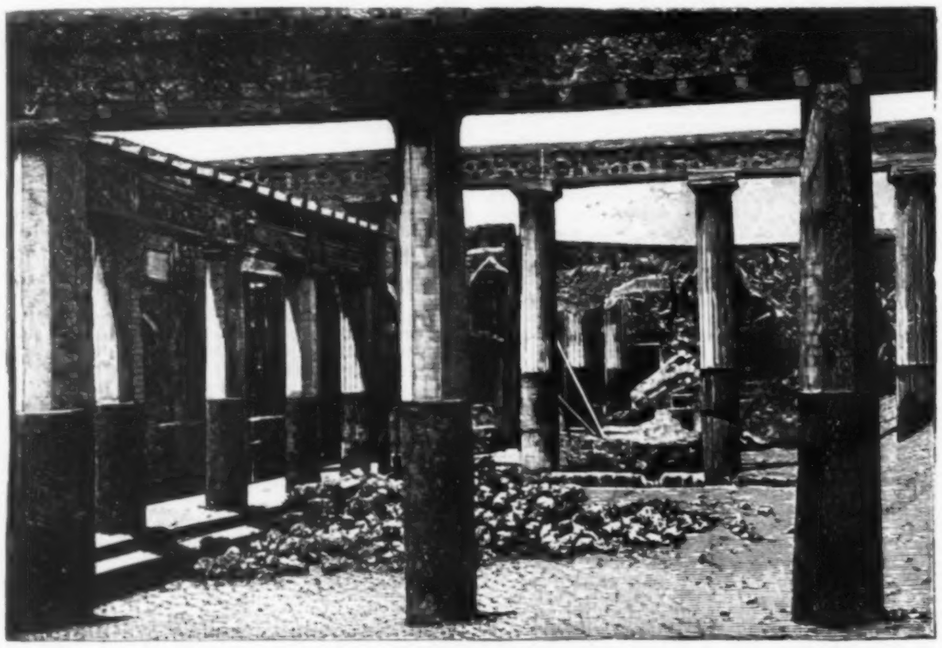
NAPLES—STREET SCENES, THE MUSEUM, A HALF DAY AT POMPEII.

Naples is said to have the most picturesque situation of any city in Europe. Whether you see it from the western suburb of Posilipo, or from the heights of St. Elmo, or from the island of Capri, the blue crescent-shaped bay, the stately Vesuvius, and the mountains of the Sorrentine peninsula are all included in the panorama. The city skirting the bay for miles, and climbing the hillsides around it, is inseparable from the rest of this picture, and the red and cream colored buildings add much to the beauty of the scene. But when the fair picture is out of sight, because one is actually among the streets of the city, what a contrast to the loveliness of s.tuation is presented! It is true that there are imposing public buildings and fine statues, and the park and drive along the shore are fine, but they do not, singly or collectively, impress the stranger as do the narrow streets and the life that crowds them.

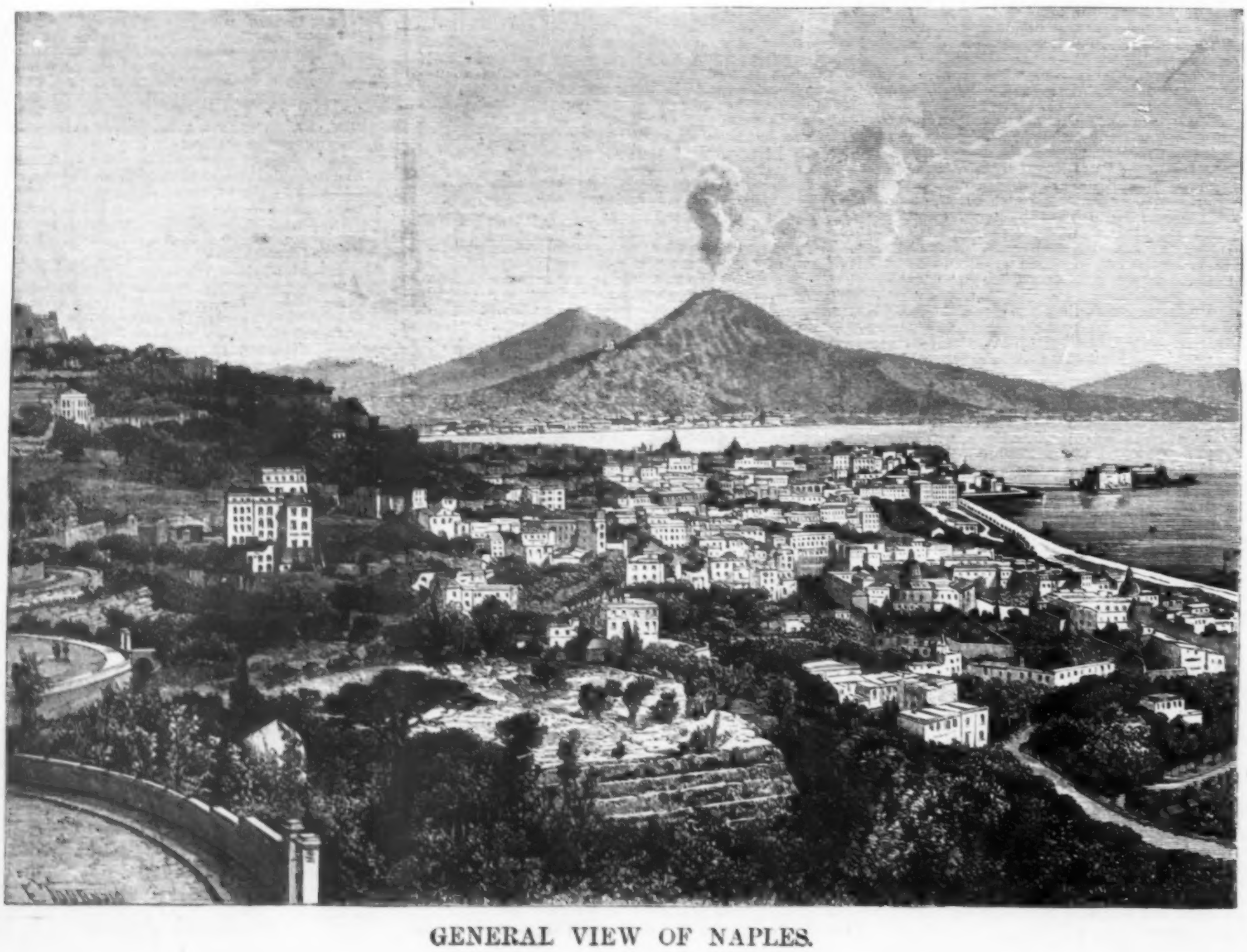
More than in any other city where I have been do the people seem to be the city. I catch myself wondering what the houses are for, because all the occupations and avocations of life are going on in the street. And the narrower and more crooked and dark it is, the more there is going on.

The lower stories of all the houses in such streets form den-like dwelling places. They are without windows, and though the door is always wide open, it is easy to see that the light in the back part is always dim. So the people live on the outside. Here a woman has a little stove near the door, the pipe is propped up by two old chairs, and she hangs the clothes she is ironing upon them. Her neighbor has her two chairs a few feet apart, and on the old rope stretched between them she is drying her washing. Very near, a family is gathered around a little table for a meal. It is said that the poorer Neapolitans eat but one meal a day. If this is so, I should say the time for taking it must range from sunrise to sunset. It is so common to meet people eating anything, from a chunk of bread to a tomato, as they walk about the streets, that one soon hardly notices it. Shoe makers, and dress makers, and tailors have their sewing machines, just in the doorway or even outside it, and they are working, busily; sometimes a good sized table is surrounded by "hands," and they are making up fine and pretty fabrics. Everywhere in Italy people carry loads on the head, but here they are heavier than those I have seen in other places. I have met a man with a large door on his head, and another carrying a mattress and iron bedstead.

The children swarm; they are pretty, nearly all of them, but dirty and ragged, some are actually naked. Can it be possible that they will ever grow up to be so ugly and bent, so withered and toothless, as are the old people who constitute a large part of the begging class? Yes, very likely; for already the little ones who are scarcely old enough to talk are learning to run along beside a carriage and wink or whine for the



A HOUSE AT POMPEII.



GENERAL VIEW OF NAPLES.

soldi they are bound to do their best to get from the stranger who happens into their quarter.

The loose dirt in the streets is appalling. Poor little donkeys with big baskets upon their backs into which the offal is loaded are being driven about all the time, but they do not get around often enough to make any visible impression on the refuse. Donkeys and goats and cows and calves are mixed up with the people as I never saw them in a great city before. It seems an incredible statement to make in regard to a place of 500,000 inhabitants, but I have it from trustworthy citizens, that the milk is distributed entirely by driving the cows or goats to the door and milking them there. I saw the process a number of times, and the size of the herds one meets morning and evening confirms the statement. It is said, that even with this precaution, to prevent the milk from being watered, the milkers sometimes carry water up their sleeves and manage to get it into the vessel into which they milk; this has led to the use of narrow-necked bottles as receptacles for the milk.

Staircases in the streets are not so common as in Genoa, or so long as there, and it is fortunate for the donkeys and cows that this is so, as they are expected to climb them, and show that they are equal to the effort. There seems to be no more regular time for sleeping than for eating, if we may judge from the number of people whom we see lying asleep on steps of churches or in shady street corners, whenever we happen to be abroad. The streets here, as in the other Italian cities, are very noisy until far toward morning. The begging for which the Neapolitans have such a reputation has not been more annoying to us than have been the efforts of the people to earn an honest penny. When we are driving as fast as the miserable little ponies attached to the street carriages can be made to go, boys follow us and thrust flowers into our faces and urge us to buy them. If we walk, we are constantly spoken to by cab drivers who want us to take their vehicles. They follow us for long distances and are disagreeably persistent. The drivers are so ragged, their ponies are so poor and slow, and the cabs are so flea-infested that we take them only from necessity. The trams and omnibuses are filthy and cheap.

These people who are working hard, as great numbers of them certainly are, and are so ragged and dirty, appeal very much to our sympathies. Their fellow-citizens in better condition tell us that they are not so poor as they look; that some of those who beg do it from choice, not necessity, as an easy change from regular employment; that it costs so little to live here, that if they wished to be more decent, they could be. I can vouch only for the statement that rags and toil and wretched conditions abound.

Priests are very numerous on the streets, and confessionals almost touch each other in the aisles of the cathedral.

It is said that the lottery sanctioned by the government is one important cause of misery; certain it is that the places where tickets are bought or drawn are very numerous; we see the signs along the best streets.

The common people speak a corruption of the language difficult for a stranger to understand.

A large portion of the aristocracy of Naples is away in country villas; we are seeing the city at a time when the poor are perhaps more conspicuous than at other seasons. But we who are accustomed to the summers along the latitude of 42° to 46° in the interior of the United States are not troubled by the heat. Staying indoors, protected by these walls impenetrable to heat, for about three hours in the middle of the day, we have no discomfort in being out at other times.

The sea breeze is almost constant; the evenings are delightfully cool; a good authority states that "the thermometer rarely rises above 85° Fahrenheit in the shade."

The museum in Naples is its chief object of interest to lovers of art and antiquities. The building itself has had an interesting history. It was used as a stable in the last part of the sixteenth century, but the inadequate supply of water led to its abandonment for that purpose, and it was given to the university. Law courts were afterward held in it, and later still troops were quartered there. Ferdinand IV. added an upper story to it in 1790, and placed the objects taken from Pompeii and Herculaneum, as well as other valuable collections, in the building. In this century many valuable contributions have been acquired by gift and purchase.

Nothing interested me so much as the objects which have been brought from the two long-buried cities, and what time I have had for the museum I have spent in looking at these.

They are most instructive upon the taste, the habits, the employments and the general civilization of the Romans at the beginning of our era. The mosaics are among the objects which most surprise and delight the modern eye. The largest of these is about twenty

BODIES DISCOVERED AT POMPEII.

THE STREET OF TOMBS, POMPEII.

feet long and half as wide. It represents the battle of Issus, and was taken from the House of the Fawn in Pompeii. Alexander, mounted on Bucephalus, is pursuing Darius in his chariot. In all 26 men and 16 horses are distinguishable, although about a third of the mosaic is imperfect. The million and a half bits of marble of which it is composed are mainly black and shades of red and brown; they are so beautifully combined that one admires their harmony almost as much as the spirit of the figures which they form. The "Cave Canem" mosaic, the name of which is so familiar, is placed on the wall of a room filled with small mosaics. The dog is black, and he stands out from his white background with so much life that we can hardly believe that the Tragic Poet could ever have needed any other defense for his house; and the guest who ventured to enter must have been very sure of a different welcome within. In this room very rich mosaic columns found at Herculaneum have been placed. They are in conventional designs, in soft blues, reds and yellows.

There are many rooms filled with bronzes. Some of them are in perfect preservation; others have rusted in places; many have taken on the rich bluish-green of corrosion. This is true of some recently found trumpets; they are delicate in form; the mouth-piece is small, and the tube, bent almost to a circle, is slender and not less than nine feet long. There are quantities of bronze gladiatorial helmets, made to cover the face entirely, except the eyes, and breastplates heavy enough to serve well their purpose. Of what are called the small bronzes, there are about twenty thousand in the collection. They include objects of deepest interest from the light they throw upon the time; here are many lamps, beautiful in design and finish; carpenters' and gardeners' tools; locks and keys; stoves and braziers; kitchen utensils, including colanders and ladles.

The surgical instruments show that the knowledge of anatomy must have been excellent. Almost the only large bronzes of antiquity are in the third hall of the museum. Of these a drunken faun, two foot runners just starting on a race, the sleeping faun and Mercury, breathless from his rapid flight, were all found in a villa garden at Herculaneum. They all show a master's treatment.

The head known as that of Plato, and also as the "Indian Bacchus," is by some considered the finest bronze head in the world. The long hair is bound with something like a fillet, and each hair is distinct; the beard is curled, the strong features are set in an expression of dignified thought. There are many life-sized figures of goddesses, dancing girls, etc., made most lifelike by their pose and enamel eyes, their carefully modeled faces and graceful drapery.

There is a large quantity of small bronze figures—lares and penates. Many rooms have their walls covered with frescoes from Pompeii. These were painted upon the wall, while the plaster was wet, it is stated, and their fine preservation is accounted for in this way. It is true that some are so indistinct as not easily to be made out, but many are so fresh that one finds it hard to believe that they have been under a mass of ashes for centuries. Artists discover errors in perspective in these pictures, but they also find in them delightful coloring, grace and spirit and finish; while to the archæologist they give much information confirmatory of inferences he has made from other remains. Two of the best pictures represent Medea considering the murder of her children; in one, she stands alone, her face depicting a conflict of feeling; in the other, the children are with her. There are domestic and street scenes, which help us to people the city again, in imagination. Many subjects are Homeric. Two large cases contain pigments found in a shop in Pompeii. They are in powder, balls and chunks, in red, blue, ocher, etc. It is said that Sir Humphry Davy analyzed specimens of these pigments and found their composition identical with those in modern use.

An accurate cork model of the excavated portion of Pompeii is, perhaps, the most interesting single object to be seen in the Naples Museum, by the visitor who finds it impossible to make the fatiguing survey of the little city.

A VISIT TO POMPEII.*

Any one who has the strength and time to spend a day at Pompeii is richly repaid for their expenditure. The most comfortable way to get there at this season, from Naples, is by train. The trip takes an hour. Two miserable little hotels and the railway station are all there is of recent origin in the place.

We enter the excavations through a long arched gateway, the old sea gate of the city, walking upon the same irregular blocks of tufa which were trodden by the Pompeiians. The little museum stands just beyond it, full of interesting objects. There are quantities of earthen wine and water jars, of unglazed red clay. Some of the wine jars are three or four feet high and pointed at the bottom. Several articles of food are to be seen, an egg, coffee, raisins, bread and cake are among those which are perfectly recognizable. But the most eloquent objects in the museum are the fourteen casts of human bodies which lie in glass cases, a ghastly line through the two rooms. It is interesting to learn how these have been made. The excavators found that all the parts of animal bodies had perished except the bones, but a perfect mould of the form was there in the mass of ashes; so they needed only to pour in the soft plaster of Paris, when it took on the very expression last upon the long quiet face, and clothed the skeleton again. In many cases, the skull and fingers are only partly covered by the plaster. So perfect are the models of the figures that the sex and race are at once distinguishable. Two negroes' bodies are among those preserved. Jewels are upon some of the fingers. A child's and a dog's bodies are to be found in this ghastly row of forms which represent the 30,000 people resident in Pompeii when the shower of ashes fell upon them. Other bodies may very likely yet be found, as only about half the city has been uncovered, but there is good reason to believe that the greater part of the inhabitants escaped.

Leaving the museum, we walk up the worn pavement and enter one of the roofless houses. It is known as the Romulus and Remus house, because it contains a mural painting of the founders of Rome being suckled by the wolf. Like all the Pompeiian homes of the better class, it had an inner garden, around which the rooms were arranged. The walls of this garden are decorated with paintings of elephants, oxen, peacocks, etc. The partition walls of the house are of brick and covered with plaster. A safe which we saw in the museum was found in the atrium. Next door lived Triptolemus. His walls are thick blocks of tufa; one room had an arched roof, and that is perfect, as is its beautiful mosaic floor. The marble about the impluvium is still white. This garden was surrounded by twelve columns, which still stand; in the middle there is a square fountain basin. The walls of the garden were laid off in red panels, and on this background some pictures are yet fresh. This large house had another garden; the mosaic floor of the large dining room is in good preservation; it is of black marble, with small white blocks at regular intervals, and near the rear it is adorned with a square figure which contains four different designs in marble.

The Basilica was the first of the public buildings which we visited. It was the Court of Justice and was surrounded by two rows of columns made of brick, so placed as to give a fluted appearance to the stucco which once covered them. Under the judgment seat is an arched room, to which we can descend by a flight of steps. The one high window in this room and its other features make it probable that this was a prison. Two skeletons were found here.

The Temple of Apollo is just opposite the side entrance to the Basilica. It was profusely ornamented with bronze and marble statues, and with paintings, but they have all been carried to the Naples Museum for safe keeping. The visitor finds himself constantly regretting that treasures such as these could not have been left where they were found, but a moment's reflection shows him that they could only have been preserved in situ at an enormous expense. Most of the public buildings seem to have been close together. The worshiper at Apollo's shrine could leave the temple at the north end and be in the Forum. All around this we see the brick bases upon which stood statues, many of them equestrian, of distinguished citizens. The statues and the marbles which covered their pedestals have all been carried away. Inscriptions in the Street of the Tombs tell us who these men were. An arched entrance to the Forum, with its walls about 16 feet long, still stands—a welcome shelter on a warm day. From there we look right upon Vesuvius, plainly discern the footpath up the cone, and reflecting that its black mass has all been heaped up since Somma buried Pompeii, we have a new realization of the forces beneath this crust upon which we tread as confidently as did the eager crowd once busy in this very Forum.

At the northern end of the Forum stand what were the ruins of the Temple of Jupiter, when the city was destroyed. An earthquake, eleven years before, had seriously injured what was evidently the finest building in the town. The part nearest the sea has not been uncovered and trees are growing upon it. Close to this temple stands the arch of Nero. Upon it the equestrian statue of that emperor, now one of the most conspicuous relics in the Naples Museum, was found. It is but a step to another public building about which there is much difference of opinion. Some authorities think it was a Temple to Augustus, as five statues of the Augustus family were found in a part which they call a shrine. Others maintain that the form of a part of the structure suggests that it was a Temple of Vesta; others still find, in the decorations and in the twelve small rooms arranged on the side, convincing proof that the place was a market. There are still beautiful paintings on the walls. Among them may be mentioned one of Ulysses and Penelope, and another of a chariot drawn by spirited horses, and driven by a graceful figure.

The Baths of the Forum are sufficiently well preserved to be very interesting. From the large waiting room the bathers passed into a room which contained niches for dressing rooms. The marble plunge bath has an arched ceiling; its walls are frescoed and are further decorated with reliefs of chariot and horse races in white on a red ground. Hot baths were taken in an adjoining room, around a long bronze brazier upon which the fire was placed. The benches about it suggest the sitters, who very likely grew more quiet in argument or less confidential in gossip as the temperature rose. The decoration of this room is given by terra-cotta figures.

The House of the Tragic Poet is one of the most beautiful. The dining room has its walls decorated at the base with black, above that is red, and next comes yellow. These solid colors are the background for pictures. A Venus, in true flesh color, is selling Cupids; there are five figures in this group. A still larger picture represents Ariadne lying on the ground, as Theseus sails away; the boat with its cordage is distinct.

We walked down the Street of the Tombs, which was in a thickly populated part of the city. We went into one columbarium, which was the receptacle for a number of cinerary urns. Several inscriptions show whose tombs they are on; some high and imposing ones remain as they were found.

At the end of this street stood, so far as is known, the largest house in the city. It belonged to Diomede, who, it is supposed, was the richest citizen. Unlike all the other residences, it was two stories high; the others were only one. Running under its four sides was an arched wine cellar, through a part of which we walked. In this all the members of Diomede's family, it is supposed, took refuge when the fall of ashes became alarming. When the lava began to flow into the cellar they stood against the walls to let the stream pass, and the impression of the forms against the walls is plainly visible. Eighteen skeletons were taken from here. The house was spacious and elegant and well built. No wonder the ill-fated family thought it was safe for them to stay; no wonder they dreaded to leave so beautiful a home.

In quite another quarter of the city from that I have so far described the Tragic and the Comic Theaters have lately been partly excavated. They adjoined each other. They are amphitheatrical in shape. The quarters for the gladiators have been uncovered. Walking along around the upper row of seats, as we did, in one, we got a good idea of the general arrangement of both.

I must not go into details about shops, where the wine jars still stand in their places, nor speak of other houses, among them Sallust's, and all full of interest. The streets are all very narrow. In many places the thick paving stones have deep grooves in them, made by chariot wheels. Large blocks raised above the level of the street were evidently intended for stepping stones at the crossings. Tufa and thin bricks were the universal building material. These, as I have already suggested, were covered with mortar or marble to suit the place.

The Italian government is, at present, doing scarcely anything in the way of excavation. We saw a few men at work, making repairs.

Flowers are growing, as they always do, not only in the old gardens, but in corners of rooms where they can get a foothold. Lizards dart about with a freedom which seems to show that they know that no higher life than theirs is being lived in this city of the past.

A half a day spent in wandering in and out among the deserted walls leads one to the conclusion that the Pompeiians were art and pleasure loving people, with wealth enough to gratify their desires for both, and leisure enough to enjoy the luxuries with which they surrounded themselves. How little they dreamed that, in their statues and pictures and fountains, they were leaving the record of their lives that would be longest read! A. D.

Naples, July, 1894.

* The city of Pompeii was situated on the Bay of Naples, directly at the foot of Mount Vesuvius. In 79 A. D. it was destroyed during an eruption of the great volcano and its ruins were covered up with stones and ashes, which continued to fall for several days. Most of the buildings were of one story, the roofs and upper parts being of wood. The ground floor was usually of masonry and the remains thereof have been wonderfully preserved. The mantle or envelope of ashes, twenty feet thick, obliterated the entire city. After a while vegetation covered the surface, the site of the proud city was lost to view and became forgotten. In the course of time changes took place in the formation of the surrounding grounds, the sea receded or was filled up, so that the site of the city is now a mile back from the water. In 1755 remnants of Pompeiian buildings were accidentally discovered, and this led to systematic excavations which from time to time were and are even now slowly prosecuted.

CAIRO AS A SEAPORT.

THE land of the Pharaohs, thanks to habit, is not made for getting frightened at vast projects and grand works, of which the chain, interrupted for some centuries, has been renewed by the Suez Canal.

Since irrigation causes its wealth, there is a dream now of irrigating it to profusion as far as to the regions that the Nile sometimes forgets to visit. Something further is dreamed of, and in the projects of engineers, the day is already foreseen in which Cairo, dethroning

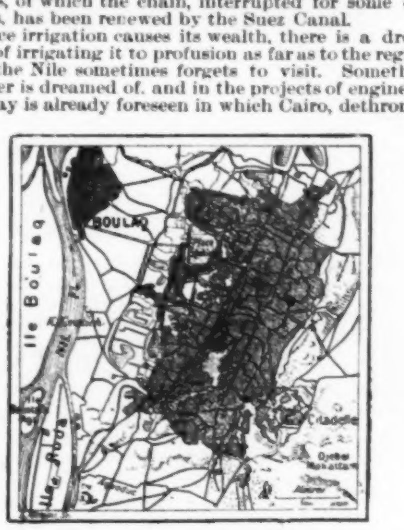


FIG. 1.—REPRODUCTION OF AN 1828 MAP OF CAIRO.

the city of Alexandria, will become a seaport. Of what is it a question, then? In the first place, of regulating the inundations of the Nile by storing the water in vast reservoirs, and for this the engineers under the orders of Mr. Willcoks, the Minister of Public Works, propose to dam the valley at every point where it is contracted. Five points have been proposed, four of which are in the main valley at Philæ, Assouan, Silsileh and Kalabcheh. The fifth, situated in the depression of the Wady-Rayan, can be set aside at once, since it would be very costly, and would, moreover, be utilized only by the region of Lower Egypt.

Mr. Prompt, a French engineer, inspector-general of bridges and highways and administrator of the Egyptian railway, has become an ardent promoter of this vast project, but, in the selection of the site that it is well to give the damming, he is not absolutely of the same opinion as the English engineers, and, for peremptory reasons, discards the different projects and allows only that of Kalabcheh to stand.

As regards the reservoirs of Philæ and Silsileh, the land would be ill adapted for the solid foundation of a dam. As regards that of Assouan, there is an impossibility of another order. The result of the construction would be to put the greater part of the temple of Philæ under water for several months. Some engineers, it is true, propose to take the temple and transplant it elsewhere, as one might do with an ordinary American building; but, says Mr. Prompt, the temple of Philæ, its island, its accessories, its memories and its situation constitute an inseparable whole. It is the theory of "en bloc" applied to archæology.

The field of the discussion thus cleared, it only remains to examine the dam of Kalabcheh; but, as regards this, at least, Mr. Prompt is going to prove to us that that unites all the conditions requisite. With a height of 25 meters it would permit of impounding more than two and a half cubic meters of water that might at the proper moment be distributed over Lower and Central Egypt and perhaps even over entire Egypt, since the capacity of the Khors (large ravines which in Nubia hollow the hills of the two banks) would considerably increase the volume of the reservoir, although this has not been taken into account in the estimates.

The entire project would entail a total cost of forty millions. It is true that Mr. Prompt estimates that it would be possible to effect a reduction of from thirteen

to fourteen millions in these figures by adopting a judicious method of foundations by compressed air and various modifications of the work as a whole.

However great the cost, one ought not to recoil from the execution, when the benefits that must accrue to the state and the country are thought of: to the state through the sale of land, through the increased value of the domain of Daira-Sanieh, and through the increase of taxes, which would be no less than twenty-four millions; and to the country through an incredible increase of its production, which, if statisticians are not deceived (as they sometimes are), ought to afford a gain of 320,000 francs at the least.

It will be at once seen that this immense increase in the wealth of the country will be attended with a considerable impulse to transportation. The weight of the merchandise coming from the regions situated above Cairo and carried with slow speed by railway to the sea does not at present exceed 300,000 tons; but it may be foreseen that the transit will rapidly reach 825,000 tons—a figure that will be quickly exceeded, since sugar especially, which will play a predominant role in the culture of Upper and Central Egypt, after the construction of the reservoir, will itself give, calculating from the surface irrigated, a production of 1,620,000 tons.

Conversely, the importations, and principally those of the coal necessary for manufacturing, will follow a corresponding movement. It will be seen that, in order to confront the new exigencies, the railway will have to proceed to double its track and construct new rolling stock and stations. All this work is estimated at 38,500,000 francs, while, in order to place Alexandria on a level with such a traffic, 10,500,000 francs will be spent thereon.

Will this be enough? It is here, says Mr. Prompt, that is proposed the question that daily presents itself in the various countries of Europe. Will it not be necessary, in the presence of such increase in traffic, to construct a great navigable waterway for disburdening the too much incumbered railways, whatever may be done, and to reduce the rates on long distance freight or that of little value? Thus, the merchandise of Upper Egypt, in order to reach the port of Alexandria, traverses a distance of from 800 to 1,000 kilometers. Such transportation, aside from the fact that it will be difficult of realization without long delays, and without serious accidents, will certainly cost excessive prices that the merchandise will be unable to pay. On another hand, coal for example now pays at Cairo a charge of forty piasters, when its value at the sea is but about eighty-five piasters. At 500 kilometers farther than Cairo it pays sixty-five piasters, a charge that is evidently exaggerated.

On the contrary, let a canal be constructed from Cairo to Alexandria, and let Cairo become a seaport, and the golden age will appear again. According to usage, the freight for Cairo will be the same as for Alexandria.

The industries will be freed from incumbrance, while, thanks to a simple and minimum duty, the coffers of the public debt will find themselves suddenly filled. Would the expense of construction be so great that it would be necessary to recoil before it? Listen to the promoter of this grand project. This canal, says Mr. Prompt, will connect with the sea near the port of Mex. At its narrow part, it will traverse Lake Mariout, and follow a direction line a little different from the Nubarieh canal, and will be far at the right of the dam, at a height of 4 meters beneath the low water mark of the Nile at this point, and will then run up to and opposite the bridge of Embalech. From this point upward there will be constructed a basin capable of accommodating thirty large ships coming alongside of wharves where terminate railways starting from the station of Boulaq-Dacrour.

Mr. Prompt estimates the work necessary at nearly twenty-one million francs for the canal properly so called and at seven millions for the port of Cairo, say a modest total of twenty-eight millions.

It is certainly only timid people who will ask for the carrying out of this enterprise that it be delayed until the reservoir has been constructed and given some results.—La Nature.

The United States is the soberest and most temperate country in the world. The compact population of England and Wales has a public house for every 202 persons, while the United States has one for every 450 persons.

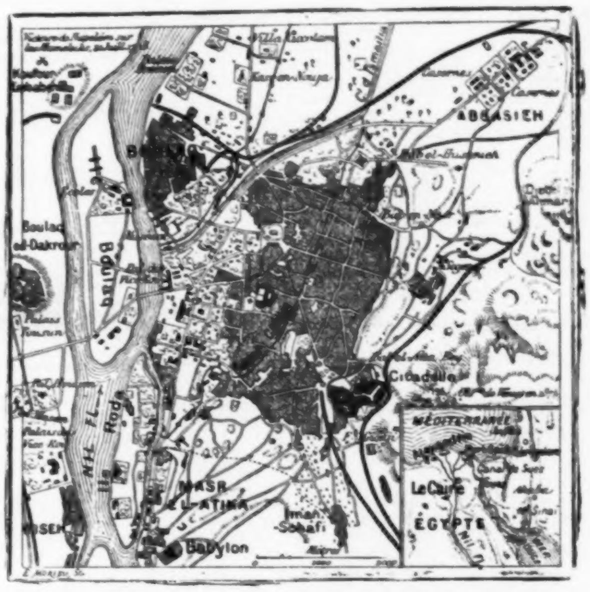


Fig. 2.—REPRODUCTION OF AN 1894 MAP OF CAIRO.

THE SIXTH SUMMER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

By E. O. Hovey.

In the absence of the president, Prof. T. C. Chamberlin, who is spending the summer in the Arctic regions, the sixth summer meeting of the Geological Society of America was called to order Tuesday morning, the 14th inst., by the first vice-president, Prof. N. S. Shaler, of Harvard University, at Packer Institute, in Brooklyn. He feelingly referred to the deep and abiding sorrow the society has been called upon to bear in the death, on the 7th of July, of Dr. Geo. H. Williams, professor of inorganic geology in Johns Hopkins University, who was the second vice-president of the society this year. Prof. Williams was a promising geologist, and had a brilliant mind, and his removal is a great loss to the science of geology in America, as well as an irreparable blow to his friends, of whom he had a host. Eleven new fellows were declared elected, making the total present membership of the society 229. A communication from the Royal Society of London was read, asking for aid and co-operation in the publication of a complete subject and author catalogue of scientific periodical literature. This vast undertaking, in which the Royal Society has asked the help of all the great libraries and scientific bodies of the world, is one of great importance to scientific and technical men, and a committee was appointed to consider the matter and report at the next meeting of the Geological Society in December. Twenty-eight papers were presented in the programme, but the absence of the authors reduced the number actually read to fifteen.

The first paper was by Prof. J. F. Kemp, of Columbia College, and described with maps sections and specimens the famous nickel mine at Lancaster Gap, Pa., and the pyrrhotite deposit at Anthony's Nose, on the Hudson. Of late years nickel has been increasing in scientific interest on account of its occurrence in meteorites and in basic igneous rocks, and in technical interest on account of its use in hardening steel for armor and other uses. Vein deposits of nickel ore are not important in America, but the sulphide ore, together with iron, chromium and other metals, are disseminated through basic igneous rocks, and great masses of nickeliferous pyrrhotite (magnetic iron pyrites) are associated with gneissic rocks. The "Old Gap" mine has been known since 1718, and was worked for copper for more than a century. In 1852 the late Dr. F. A. Genth, of Philadelphia, discovered nickel in the ore. About ten years later Joseph Wharton obtained possession of the property and rapidly raised it to the rank of one of the foremost nickel producers in the world. Of late years the ore has been thinning out, and last winter the mine was exhausted, the works dismantled and the property abandoned. The nickeliferous pyrrhotite here was associated with copper pyrites and was disseminated through a basic, intrusive rock, but was especially concentrated along the contact of this lense or pod of intrusive rock, and the surrounding schists. The ore-bearing rock is essentially of green hornblende, and the ore together with a little brown mica. Where the ore is less abundant, feldspar comes in, and it is probable that the rock was originally a gabbro. There are two theories to account for the concentration of the ore—one that they have segregated from the originally fused mass by the law that those chemical compounds which solidify first tend to concentrate in the part first cooling, the other theory is that the concentration is a contact phenomenon. The author, after studying the great deposits at Sudbury, Ontario, inclines toward the first theory for both, since the sulphides are the first substances to solidify from igneous magmas. The great pyrrhotite masses in acid gneisses at Anthony's Nose, on the Hudson, and at various places in New England, carry nickel, but the amount is so small as not pay for extraction. From this it seems that basic rocks are necessary to rich occurrence of the nickel sulphides.

The connection between the chemical and optical properties of amphiboles was next discussed by Dr. A. C. Lane, of Houghton, Mich., whose experiments and collation of other data go to show that the strength of double refraction on certain sections of the crystals is inversely proportional to the amount of soda present.

The paper of Prof. C. H. Smyth, Jr., of Clinton, N. Y., described the results of some recent work on a dark-colored, massive rock associated with the iron ore (hematite) at the Old Sterling Mine in Jefferson County, N. Y., which has been called serpentine since its description by the early New York geologists. Its origin has always been a matter of doubt, but the author's examination in the field and with the microscope shows that the rock has been derived from granite, though greatly altered from its original condition. The paper briefly outlined the character of the changes which the rock has undergone, and suggested that the alteration is due to crushing of the rock by regional disturbances, together with the infiltration of solutions derived from decomposing iron pyrites in a neighboring older gneiss. The derivation from granite of such a basic rock as this so-called serpentine is very remarkable.

Dr. E. O. Hovey, of the American Museum of Natural History, in this city, gave the results of a study of some specimens of chert from Missouri. These cherts are from the cambrian(?) and lower carboniferous strata. The former are not fossiliferous, while the latter are frequently highly so. The rock, except for the calcareous fossils, is almost entirely chalcedonic silica, either in mottled mossaic or concretionary forms. No sponge spicules or radiolaria are present, and the silica is held to be of entirely inorganic origin.

Matters of local geological interest were touched upon by Mr. C. A. Hollick, of Columbia College, in his paper on "Dislocations in Certain Portions of the Atlantic Coastal Plain Strata and their Probable Causes." The strata referred to are the preglacial clays and gravels. Disturbances, apparently due to causes identical with or similar to mountain-making forces, have been recognized in the South by several observers, notably by Dr. W. H. Dall, in Florida; and certain contortions in the clays of Gay Head and other parts of Martha's Vineyard have been attributed to the same forces by Prof. N. S. Shaler. In the South the lines of disturbance are in the direction which past experience would naturally lead us to expect, viz.: generally north and south, parallel with previous lines of disturbance in the Appalachian region. In the North the line of disturbance, which includes Martha's Vineyard, may be traced through Long Island, Staten Island, and New Jersey, or in a generally east and west direction; the exact opposite to that which we would expect. The author's investigations in the northern region, especially at Kreischerville and elsewhere on Staten Island, and at Cold Spring Harbor and many other places on Long Island, have lead him to the conclusion that the pressure due to the advance of the great ice sheet has been the crumpling agent. The primary objection to the mountain-making theory is on general principles, the line of disturbance being in the opposite direction to what would be expected. In the second place, numerous erratic features of dip and strike in the disturbed strata are not readily accounted for in this way. The argument for assigning the disturbance to ice action is based largely upon the invariable coincidence of the presence of the disturbed strata with the terminal moraine and their absence elsewhere. The erratic dip and strike of the strata in places seem to be due to squeezing and shoving from the general direction of ice advancement and lateral pressure from tongues of ice deeper than or ahead of the main mass. In the discussion following this paper Prof. Shaler stated that the ancient river drainage on Martha's Vineyard had not been essentially modified by the thin sheet of glacial material covering the island, and that undisturbed preglacial clays lay in pockets on top of the contorted strata at Gay Head, and that, therefore, the disturbance there could not have been caused by the agency of ice.

What was probably the most important paper read at the meeting was that by Dr. J. W. Spencer, of Atlanta, Ga., entitled the "Reconstruction of the Antillean Continent." It would be impossible to give here a compendious resume of the article, as it is very long. The author has been studying the subcoastal plain or bench outside the 100 fathom line from Cape Hatteras to the northern coast of South America, and at the 10,000 ft. line he finds a steep escarpment. Submerged plateaus occur at several places, one of the largest of which is the Blake Plateau, named by A. Agassiz, east of Florida, and 2,700 ft. below the surface. Several river channels along the southeastern and gulf coasts of the United States are recognizable as canons in the subcoastal plain, one of which is cut 5,500 ft. deep in a submerged plateau. These canons extending to such great depths and to the bottoms of the Gulf of Mexico and the Caribbean Sea are the great argument for recent subsidence to about 10,000 ft. in the northwestern part of the area increasing to about 13,000 ft. in the southeastern portion, with corresponding prior elevation in recent geologic times. At the time of elevation these land-locked seas were plains, and the drainage of the Gulf of Mexico plain was into the Pacific Ocean. The author enumerated the changes of level which the area has probably had since cretaceous time and compared the strata which were formed in the West Indies and the southern part of the United States at the same time. He called attention to the fact that the high mountain land of Cuba and other islands would support different species of animals from the much lower land of Florida, even if there were land connection with the continent. Present study tends to disprove the theory that the Strait of Florida owes its origin to the action of marine currents.

Prof. N. S. Shaler then gave an interesting discussion of the "Evidences as to the Change of Sea Level," taking up the theory advanced by the Greek geographer, Strabo, 1900 years ago, that there were rise and fall of the sea bottom as well as elevation and depression of the land surface. This theory of differential movement has received much study of late years. Such movement is similar to that of a lever about its fulcrum. The fulcrum line will not correspond closely with the coast line, however, and whether the sea or the land gains depends upon whether the fulcrum line is within or without the coast line. When the two coincide, neither sea nor land will gain. Swaying of the sea bottom has been great, as is shown by the subsidence of some and the elevation of other Pacific coral islands. The forces at work always present a very complicated equation. The study of submerged river valleys shows recent subsidence and the rare occurrence of salient river deltas indicates the same thing. The sea is now gaining on the land as a whole.

Mr. W. J. McGee, of the North American Bureau of Ethnology, followed in the same strain in his paper on

"The Extension of Uniformitarianism to Deformation." He cited the changes of relative elevation that have taken place all over the world within historic time, in all of which the vertical displacement has been vastly greater than the horizontal. Only one-sixth of the territory of the United States, aside from Alaska, shows mountain making, with contorted strata which have been moved horizontally. The one-twelfth lying in the Great Basin region and elsewhere in the great plateau region discloses phenomena which can be explained only by vertical displacement. The remaining three-fourths of our land shows considerable vertical movement to have taken place with only insignificant horizontal displacement. Orogenic or mountain-making movements are but local and temporary, while epirogenic or continent-making movements are widespread and continuous. The tendency almost up to the present day has been to generalize on the basis of the comparatively rare and aberrant orogenic phenomena, rather than on the basis of the common facts of the plains and the continents.

According to the scheme of classification of papers adopted by the council of the society, the glacial geologists then had the floor, but some of the most important contributions were not read, because their authors were not present. Dr. D. F. Lincoln, of Geneva, N. Y., gave a description with diagrams of drumlins in the vicinity of Lakes Canandaigua, Geneva and Cayuga in Central New York. There are many of these long, narrow ridges parallel to each other and trending a little west of north. Almost all are capped with stratified gravel and some have clay above the gravel. Recent and old sections of these hills made by roads and railroads show the hills to be true drumlins and that a rock nucleus is not necessary to the formation of such glacial hills.

Mr. Geo. H. Barton, of Boston, Mass., followed with a description of channels on drumlins caused by erosion of glacial streams. His paper dealt with drumlins in eastern Massachusetts and was illustrated with diagrams and numerous excellent photographs. Typical drumlins are among the most durable of hills, on account of their shape. Valleys of construction (formed during the aggregation of the hill) frequently separate these hills, and may come down to the bottom of the hill or not. Subordinate channels groove the hills from near their northern ends continuously to the south. Some drumlins, however, have small transverse channels, and one in Haverhill shows a channel beginning near the northeast end, cutting parallel to the long axis southward, then traversing the axis and afterward continuing parallel to the axis to the southwest end. All these channels are above the drainage level of the surrounding country, and must have been carved when something, most probably the ice, filled or partly filled the valleys. It is hoped that work along this line will assist in solving the problem of the origin of drumlins.

Stratigraphic geology next occupied the attention of the society. The reading of several synoptical papers was omitted in the absence of their authors. Dr. J. P. Smith, of the Leland Stanford, Jr., University, detailed the results of work on the triassic and jurassic groups of Shasta County, California, and showed by means of the correlation of fossils that the province is similar to the strata of the same age in the Tyrolean Alps and in the Himalayas. His studies show that the uplift and metamorphism in the mountains of northern California took place before cretaceous times.

Prof. H. S. Williams, of Yale University, discussed the age of the important manganese-bearing strata near Batesville, Ark. The State geological survey held that the concentration of these ores was due to the decay in situ of a heavy bed of limestone. Prof. Williams differed from this view, because he found the manganese ore in a regular shale lying on the eroded surface of a limestone of the age of the Trenton limestone of New York State. The manganese ore, therefore, instead of being a deep sea deposit in this case, was deposited in swamps or shallow water on the slightly elevated limestone. This leads to a subdivision of the strata somewhat different from that given by the State survey.

A report of the progress of geologic science between the Centennial Exposition at Philadelphia and the Columbian Exposition at Chicago was one of the projects of the committee on awards in the Department of Mines. Mr. J. Hotchkiss, of Staunton, Va., was asked to prepare such a report. He stated to the society that 40 States and Territories and 33 foreign countries were represented in the Mining building, and that he had asked a representative geologist in each district to prepare a concise statement showing by maps and descriptive text the changes in the knowledge of the geology of that region during the period of seventeen years in question. All these reports will be assembled and published with the maps and diagrams in a volume, which will appear in about a year, and will be a valuable compendium for every working geologist.

An anthropological paper crept into the Geological Society, in the shape of the description of an unusually perfect skeleton of a platycnemic man found near Canandaigua Lake, N. Y., by Prof. W. H. Sherzer, of Ypsilanti, Mich. This is an ancient and interesting type of man, showing besides the cranial development of low order, the compression of the thigh bone and the perforation of the humerus.

The meeting was practically closed by the giving of an abstract of Mr. H. W. Fairbanks' (Berkeley, Cal.) paper entitled "A Review of our Knowledge of the Geology of the California Coast Ranges." The author had first to define the coast range. The rocks may be classified as, 1, igneous; 2, precretaceous; 3, cretaceous, tertiary and recent. The precretaceous rocks, which are of rather uncertain age, are separated by an unconformability from the succeeding strata. The mountains have a core of crystalline rocks which, instead of being cretaceous, as has commonly been supposed, may be as old as triassic or even carboniferous time.

About sixty persons attended the various sessions of the society. After passing a vote of thanks to the authorities of Packer Institute, for courtesies rendered the society, adjourned to merge itself into Section E of the American Association for the Advancement of Science, which held its forty-third meeting in the Polytechnic Institute, Brooklyn, on August 16.

THE LIMITATION OF TUBERCULOSIS.

THE following is an abstract of the address of Dr. W. W. Alleger, of the Howard University, before the American microscopists, in session last week in Brooklyn.

The last twelve months have marked an era in the prophylaxis of tuberculosis. The disease, more commonly described as "consumption," is now known to be infectious, and therefore preventable. This dreadful malady is directly responsible for one-seventh of the entire mortality of the race, and one-fourth of deaths from this cause occur between the ages of 20 and 40 years. General apathy is now the greatest foe. If as many deaths occurred from cholera, or from diphtheria, as from tuberculosis, there would surely be a popular uprising for its extermination The public need to be fully assured that, thanks to the discoveries of Robert Koch and his co-laborers, we can diminish and even stamp out this scourge.

The bacillus tuberculosis is a minute, rod-shaped vegetable organism, easily recognized by its morphology and its staining peculiarities. It is found in the sputum of its victims, also in fresh caseous masses, in glands, bones, excretions from the bowels, and in the milk of tuberculous cows. The bacilli may retain their vitality for months and years in dark crevices; but exposure to the direct rays of the sun destroys them quickly. Their port of entry to the living subject is through the lungs or the stomach. The popular idea that tuberculosis is hereditary cannot be maintained; though it is true that a vulnerable type of tissue may be thus transmitted. Having once, in any manner, gained access, the work of the bacilli is aided by poisonous chemical products elaborated in their cells, and thus nodules are developed which constitute the essential lesions of tuberculosis. These nodules undergo degeneration, and the debris is thrown off in the sputum, the secretions of the milk glands, the bowels or the urinary organs. If this debris is carelessly allowed to become dried and mingled with the dust, and thus inhaled, there is danger of constant reinfection on the part of the consumptive patient.

Clinical evidence proves the communicability of this disease. For instance, a family of nine persons moved into a house that had previously been inhabited by tuberculous patients. Three of the nine soon showed symptoms of the disease. The house was supposed to have been thoroughly cleaned, but bacilli were found in the wall paper. Many cases are on record. A commitee of the British Medical Association reparts 261 tuberculous cases, of which 158 were known to have been caused by contagion through marriage to consumptive persons. One patient lost four wives in succession, another three, and four two each. Mortality statistics show of every 1,000 deaths of tuberculosis 103 farmers, 108 fishermen, 121 gardeners, 122 agricultural laborers, 167 grocers, 290 tailors, 301 drapers, and 461 printers. Among Cornish miners 60 per cent. of the deaths are from this cause; in Austrian prisons 61 per cent.; in those of Prussia about 46 per cent.; in the monasteries of Bavaria 50 per cent. In the general hospital Vienna signs of tuberculosis were observed in 85 per cent. of all autopsies, while 45 per cent. of deaths were directly due to this one cause. Half the cases in the charitable wards of New York hospitals show a similar state of affairs.

Tuberculosis increases in frequency as we rise from forms of out of door life to those whose occupation requires them to remain indoors. One manifest reason for this is the frequency with which the dust of dwellings becomes freighted with germs of disease. Cornet reports that of 118 samples of hospital dust examined by him, 40 were infective with phthisical germs. It is but recently that the attention of the public has been called to the danger arising from infected milk. Hirschberger reports the instance of an owner of tuberculous cattle who withdrew their milk from the market, but fed it to his pigs; and they all became diseased, and had to be destroyed. Among the many vehicles of infection mentioned, the most novel is by means of the bites of bed bugs. Dewerve gives an example where no other means were observed. A consumptive patient had died, and the room was thoroughly disinfected. A young man, who afterward occupied it, took the disease and died. It was found that his body was badly bitten by bugs, which suggested an examination of the insects themselves. Thirty of them were used to inoculate as many guinea pigs, all of which died of tuberculosis, and it was found that 60 per cent. of the bugs were tuberculous.

In another series of experiments, the suspected bugs were placed in contact with sputum, and virulent cultures were obtained.

The foregoing facts, which might be greatly multiplied, show the importance of disinfecting infectious materials of every kind, and also of the destruction of all tuberculous animals and insects. Were this work thoroughly done, we are confident that the dreadful scourge could be eradicated. But considering the apathy on the subject, and the prevailing lack of cleanliness among certain classes of people, complete eradication can hardly be hoped for. We may, however, hope for and should take measures for the limitation of tuberculosis. This may be done by taking special care during the progress of the disease. Expectorated matter should be received in paraffined paper in metallic cups and the paper burned at least twice a day. If porcelain cups are used, they should be repeatedly cleansed by boiling water. Handkerchiefs should never be used to receive such poisonous matter. An important precaution is, that the sputum should never be allowed to become dry, before being destroyed, for in that event it is liable to be mingled with the dust of the room and become a source of disease. Auto-inoculation on the part of attendants should be guarded against. Isolation or quarantine may not be necessary. It is a relief to be assured that the expired air from the lungs does not contain the germs of this disease, but they do frequently lodge on the lips, and therefore kissing is to be avoided. There is no danger to nurses, friends, and other associates of the patient, so long as contact with the sputum and other infected discharges is strictly shunned.

Remember that strong sunlight is fatal to the bacilli, and that thorough ventilation carries them away from the abode. We must insist on the disinfection of rooms, clothing, bed linen, and table ware used. This can usually be sufficiently done by boiling water. Tuberculous mothers should not nurse their infants unless they would communicate the disease. Dairies and abattoirs should be inspected. All meat should be thoroughly cooked in order to destroy any lurking germs of disease. Milk should be sterilized, especially for children. Separate hospitals, without the city limits, should be erected for tuberculous patients, and these should be in dry and healthy localities.

It is encouraging to know that the sanitary authorities throughout the world are waking up to the imperative necessity of taking suitable measures to restrain this distressing and fatal malady. The New York City health department is in advance of most others in the thoroughness of its surveillance. Much attention is also given to the matter by the authorities of Philadelphia and other large cities. In closing we may quote the four rules laid down by the Pan-American Congress for the limitation of tuberculosis. 1. It may be done by notification of physicians and householders. 2. By regulation of the residences of tuberculized patients. 3. By controlling the movements of such persons. 4. By establishing hospitals for the use of the infected poor.

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